



LEGENDS OF SOUTH AFRICAN SCIENCE



science
& technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA



Celebrating 20 years
(1996 - 2016)
in the service of society



LEGENDS OF SOUTH AFRICAN SCIENCE

Cover:
Oblivion of the Waves
sculpture created by
Anton Smit



| FOREWORD |

The Academy of Science of South Africa (ASSAf) celebrated its 20th anniversary in 2016, a significant milestone for South Africa's national science academy, established shortly after South Africa's first democratic elections and granted a Parliamentary statute in 2001.

In celebrating 20 years of service to society, ASSAf is mindful of the fact that its greatest strength is its Membership. It is the elected Members, all distinguished scholars that give ASSAf its unique character and set it apart from other statutory bodies in the national science system.

As part of its year-long anniversary celebrations, ASSAf here documents and contextualises the contributions made by some of the longest standing and most distinguished Academy Members. They have been selected because they have been recipients of at least one of South Africa's top awards, viz. the ASSAf Science-for-Society Gold Medal, National Orders of Mapungubwe and Baobab bestowed by the President, or the Harry Oppenheimer Fellowship.

Their stories are absorbing, their contributions to knowledge production immense, and their service to society diverse and inspiring. This provides a unique collective perspective on contributions by South African scientists and scholars. It is anticipated that these profiles of ASSAf Members will be the first in a series of profiles that will be made available as an electronic repository in the future.

This has been an uplifting project on which to work. I would like to thank all those Members who agreed to be interviewed, particularly those who were reluctant to reveal personal details, preferring to focus on their work rather than themselves. Several writers wrote the contributions and thanks are due to John-Butler Adam, Engela Duvenage, Jenny Leonard, Andrea Meyer, Anina Mumm and Linda Nordling, for their excellent work. Acknowledgments are also due to ASSAf staff for making this book a reality; Phyllis Kalele, who was the director on this project, assisted by Renata Venier, and Patricia Scholtz, who was responsible for editing and overseeing the production process. Finally, the Oppenheimer Memorial Trust is thanked for providing partial funding that enabled the production of this book.



Roseanne Diab
Executive Officer

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| ACRONYMS | ABBREVIATIONS |

| | | | |
|----------|--|--------|---|
| AAS | African Academy of Sciences | CODESA | Convention for a Democratic South Africa |
| AAAS | American Association for the Advancement of Science | CoE-SM | Centre of Excellence in Strong Materials |
| ACDE | African Council of Open and Distance Education | COMPS | Centre of Materials and Process Synthesis |
| ACPE | Advisory Committee for Polio Eradication | CPM | Column Profile Map |
| AICHe | American Institute of Chemical Engineers | CSI | Crime Science Investigation |
| AIDS | Acquired immunodeficiency syndrome | CSIR | Council for Scientific and Industrial Research |
| AIMS | African Institute for Mathematical Sciences | CT | Computed Tomography |
| ANC | African National Congress | DAAD | German Academic Exchange Service |
| AR | Attainable Region | DAMTP | Department of Applied Mathematics and Theoretical Physics |
| ARI | Agricultural Research Institute | | |
| ARV | Antiretroviral | DBSA | Development Bank of Southern Africa |
| ARVC | Arrhythmogenic right ventricular cardiomyopathy | DEFRA | Department for Environment Food and Rural Affairs |
| ASCLME | Agulhas and Somali Current Large Marine Ecosystems | DIC | Diploma of the Imperial College London |
| ASLM | African Society for Laboratory Medicine | DNA | Deoxyribonucleic Acid |
| ASSAf | Academy of Science of South Africa | DOE | Department of Education |
| A*STAR | Agency for Science, Technology, and Research | DHET | Department of Higher Education and Training |
| AU | African Union | DSc | Doctor of Science |
| BA | Bachelor of Arts | DST | Department of Science and Technology |
| BMJ | <i>British Medical Journal</i> | EBIT | Engineering, the Built Environment and Information Technology |
| BSc | Bachelor of Science | | |
| CA | Chartered accountant | ECHO | Enhancing Children's HIV Outcomes |
| Caltech | California Institute of Technology | EMSSA | Electron Microscope Society of Southern Africa |
| CANSA | Cancer Association of South Africa | ESAR | Eastern and Southern Africa region |
| CAPRISA | Centre for the AIDS Programme of Research in South Africa | FABI | Forestry and Agricultural Biotechnology Institute |
| CCESSA | Cryo-conservation Centre of Excellence for sub-Saharan Africa | FAO | Food and Agriculture Organisation |
| | | FDE | Further Diploma in Education |
| CDC | Centres for Disease Control | FOCAPD | Foundations of Computer-aided Process Design |
| CEO | Chief Executive Officer | FPD | Foundation for Professional Development |
| CHAVI-ID | Centre for HIV/AIDS Vaccine Immunology and Immunogen Discovery | FRF | First Rand Foundation |
| | | GMC | Grant Medical College |
| CHE | Christian Higher Education | GMO | Genetically Modified Organism |
| CHIVA | Children's HIV Association | GSK | GlaxoSmithKline |
| CIDA | Canadian International Development Agency | HESA | Higher Education South Africa |

| | | | |
|---------|---|--------|---|
| HHMI | Howard Hughes Medical Institute | MD | Doctor of Medicine |
| HIV | Human Immunodeficiency Virus | MEL | Molecular Engineering Lab |
| HMBASA | Human Milk Banking Association of South Africa | MISTRA | Mapungubwe Institute for Strategic Reflection |
| HPLC | High-Performance Liquid Chromatography | MMed | Master of Medicine |
| HPTN | HIV Prevention Trials Network | MRC | Medical Research Council |
| HRC | Human Rights Commission | MRI | Magnetic Resonance Imaging |
| HSRC | Human Sciences Research Council | MS | Mass Spectrometry |
| HVTN | HIV Trials Network | MSB | Millennium Seed Bank |
| IAS | International AIDS Society | MSc | Master of Science |
| IAPAC | International Association of Physicians in AIDS Care | NACI | National Advisory Council on Innovation |
| IBPGR | International Board for Plant Genetic Resources | Nafcoc | National African Federated Chamber of Commerce and Industry |
| ICC | International Association of Cereal Science and Technology | NAMDA | National Medical and Dental Association |
| ICDE | International Council for Open and Distance Education | NASAC | Network of African Science Academies |
| ICI | International Congress of Immunology | NBG | National Botanical Gardens |
| ICDIM | International Conference on Defects in Insulating Materials | NBI | National Botanical Institute |
| ICMI | International Commission for Mathematics Instruction | Necsa | South African Nuclear Energy Corporation |
| ICSU | International Council for Science | NEPAD | New Partnership for Africa's Development |
| ICT | Information and Communications Technology | NGO | Non-governmental Organisation |
| IDM | Institute for Infectious Disease and Molecular Medicine | NICD | National Institute for Communicable Diseases |
| IMCB | Institute for Molecular and Cellular Biology | NIH | National Institutes of Health |
| IMPAACT | International Maternal Paediatric Adolescent AIDS Clinical Trials | NIV | National Institute of Virology |
| IOM | Institute of Medicine | NHLS | National Health Laboratory Service |
| IPGRI | International Plant Genetic Resources Institute | NLC | National Laser Centre |
| IUCN | International Union for Conservation of Nature | NMR | Nuclear Magnetic Resonance |
| IUFRO | International Union of Forest Research Organisation | NOAA | National Ocean and Atmosphere Administration |
| IUPAC | International Union of Pure and Applied Chemistry | NRF | National Research Foundation |
| ISSS | International Society for Seed Science | NSSL | National Seed Storage Laboratory |
| ISTA | International Seed Testing Association | NSTF | National Science and Technology Forum |
| KNAW | Royal Netherlands Academy of Arts and Sciences | NUMSA | National Union of Metalworkers of South Africa |
| K-RITH | KwaZulu-Natal Research Institute for Tuberculosis and HIV | NUSAS | National Union of South African Students |
| KZN | KwaZulu-Natal | NZG | National Zoological Gardens |
| LEM | Leukoencephalomalacia | OBE | Officer of the British Empire |
| LC | Liquid Chromatography | OIST | Okinawa Institute of Science and Technology |
| LMB | Laboratory of Molecular Biology | PAC | Pan-African Congress |
| LRC | Legal Resources Centre | PACHA | Presidential Advisory Council for HIV/AIDS |
| MaPS | Material and Process Synthesis | PAEMS | Pan-African Environmental Mutagen Society |
| MatCH | Maternal, Adolescent and Child Health | PATA | Paediatric AIDS Treatment in Africa |

| | | | |
|---------|--|----------|---|
| PATH | Programme for Appropriate Technology in Health | SASO | South African Student Organisation |
| PCR | Polymerase Chain Reaction | SAWISE | South African Women in Science and Engineering |
| PEPFAR | President's Emergency Plan for AIDS Relief | SBS | Surface Brillouin Scattering |
| PhD | Doctor of Philosophy | SERA | Southern Education and Research Alliance |
| PHRU | Perinatal HIV Research Unit | SIRG | Social Insect Research Group |
| PPRI | Plant Protection Research Institute | SKA | Square Kilometre Array |
| PROMECH | Programme on Mycotoxins and Experimental Carcinogenesis | SLE | Systemic Lupus Erythematosus |
| | | STI | Sexually Transmitted Infection |
| PU | Potchefstroom University | STIAS | Stellenbosch Institute for Advanced Study |
| RCT | Randomised controlled trial | SRC | Student Representative Council |
| R&D | Research and development | SU | Stellenbosch University |
| RDP | Reconstruction and Development Programme | WHO | World Health Organisation |
| RHI | Reproductive Health and HIV Institute | WISH | Women in Science and Humanities |
| RHRU | Reproductive Health Research Unit | TB | Tuberculosis |
| RNA | Ribonucleic Acid | TPCP | Tree Protection Co-operative Programme |
| RSSAf | Royal Society of South Africa | ToP | Termination of Pregnancy |
| SA | South Africa | TWAS | The World Academy of Sciences |
| SAAWK | <i>Suid-Afrikaanse Akademie vir Wetenskap en Kuns</i> | UCL | University College London |
| SAAVI | South African AIDS Vaccine Initiative | UCT | University of Cape Town |
| SAB | South African Breweries | UDF | United Democratic Front |
| SABC | South African Broadcasting Corporation | UJ | University of Johannesburg |
| SABIE | South African Bee Industry Executive | UK | United Kingdom |
| SACEMA | South African Centre of Excellence in Epidemiological Modelling and Analysis | UKZN | University of KwaZulu-Natal |
| | | UNAIDS | Joint United Nations Programme on HIV/AIDS |
| SACHED | South African Committee for Higher Education | UNESCO | United Nations Educational, Scientific and Cultural Organisation |
| SACS | South African College School | | |
| SADC | Southern African Development Community | UNICEF | United Nations Children's Emergency Fund |
| SAIP | South African Institute of Physics | UNIFY | Science Foundation Year |
| SAICHe | South African Institution of Chemical Engineers | Unisa | University of South Africa |
| SAIMR | South African Institute for Medical Research | UNIST | Science Teacher In-Service |
| SAJS | <i>South African Journal of Science</i> | UNMS | University of Natal Medical School |
| SALT | Southern African Large Telescope | UP | University of Pretoria |
| SAMDC | South African Medical and Dental Council | US | United States |
| SANEDI | South African National Energy Development Institute | USA | United States of America |
| SANBI | South African Bioinformatics Institute | USDA-ARS | United States Department of Agriculture – Agricultural Research Service |
| SARChI | South African Research Chairs Initiative | | |
| SASBMB | South African Society for Biochemistry and Molecular Biology | WRC | Water Research Commission |
| SASPP | Southern African Society for Plant Pathology | | |

| QUARRAISHA ABDOOL KARIM |

TOP THREE AWARDS

- Science-for-Society Gold Medal Award from the Academy of Science of South Africa, 2014
- TWAS-Lenovo Science Prize, 2014
- L'Oreal – UNESCO Laureate Award for Africa and the Middle East, 2016

DEFINING MOMENT

The podium presentation at the International AIDS Conference in Vienna in July 2010 of the results of the CAPRISA 004 trial of tenofovir gel in women that provided the first evidence that antiretrovirals can prevent sexual transmission of HIV.

WHAT PEOPLE DO NOT KNOW

I love watching good Bollywood movies.



PROTECTING WOMEN AGAINST HIV

Few AIDS researchers have done as much to help the plight of poor, rural women in South Africa as Quarraisha Abdool Karim.

Since identifying the vulnerability of this group to HIV in the early 1990s, she has worked tirelessly to understand the problem and to design tools that women can use to protect themselves against infection.

At times, it has been an uphill battle. Patriarchal structures in communities and the high levels of violence against women make HIV in these communities not just a medical problem, but also a social one. Abdool Karim has worked closely with communities in her home province of KwaZulu-Natal to build the trust necessary to produce solutions that work in practice, not just in the laboratory.

In so doing, she has created a rare window into what it means to be a young South African girl or woman living in a rural area, struggling day to day to make ends meet, while at the same time facing the ubiquitous threat of AIDS. Her work is far from over. "Young women still bear the brunt of the epidemic. It's a big challenge, but I thrive on challenges," she says.

EDUCATION AND EARLY LIFE

Abdool Karim grew up in Tongaat, a small town north of Durban. Her great-grandfather arrived in South Africa from South India to work as a liaison officer between Indian labourers in the sugar cane fields of KwaZulu-Natal and their English-speaking masters. Her father and mother were small-scale vegetable gardeners. Her parents valued education highly, but saw it as a means to a career in law, medicine or engineering. When their daughter said she wanted to study science, their response was "What kind of a profession is that?"

However, their daughter was a natural-born scientist. By the time she was two years old she discovered electricity and her curiosity led her to more and more discoveries driving her parents to get her started in school by age four to keep their sanity. School was able to fulfil her insatiable desire to learn about everything. Even though she attended a poorly resourced

school, Vishwaroop Primary School, with over 40 children in a classroom, she had inspiring and truly dedicated teachers of whom she has fond memories.

She studied science for her undergraduate degree at the University of Durban-Westville, graduating in 1981 with majors in microbiology and biochemistry. She went on to study for an Honours degree in medical biochemistry at the University of the Witwatersrand (Wits) in Johannesburg after having spent a year getting hands-on immunology experience under the mentorship of Professor Ruben Sher, one of the first clinical immunologists in South Africa to respond to the emerging threat of AIDS.

After spending the next two years working in the Iron and Red Cell Metabolism Research Unit at Wits, she returned to Durban thinking she might become a science teacher, having obtained a teaching diploma through part-time studies at the University of South Africa (Unisa). After a short teaching spell she returned to research, this time in a genetic blood disorder at the Department of Haematology, University of Natal. During this time, she was actively involved in the anti-apartheid health sector, notably in the Emergency Services Group training other activists on how to administer first aid to wounded comrades in the townships.

She met her future husband, Salim Abdool Karim, in 1987, and they married four months later. After the wedding, Quarraisha joined her husband in New York where he was studying epidemiology at Columbia University. She studied epidemiology and parasitology at Columbia mentored by Dr Zena Stein, a fellow South African who had pioneered health care provision in a black township in Johannesburg before leaving the country in the 1950s.

When the couple returned to Durban in late 1988, Quarraisha Abdool Karim took up a parasitology position with the South African Medical Research Council (MRC), undertaking non-human primate research in amoebiasis. With her community-focused background and recently acquired (and still rare in South Africa) epidemiological skills, it was not long before she moved her focus to HIV/AIDS. At the time, studies on HIV were limited and

restricted to surveys in South Africa's migrant mining population. There was scant data on HIV infection rates in the general populace.

She established the MRC AIDS Programme in KwaZulu-Natal in 1989 and performed one of the first community-based epidemiological studies of HIV infection in South Africa in 1990. It piggybacked on a Department of Health malaria surveillance programme that involved house-to-house visits in rural KwaZulu-Natal, collecting blood for malaria screening. The survey, which screened 5 000 people of all ages, found that 60 people were HIV positive, a prevalence of 1.2 per cent. When she repeated the study a year later, the prevalence had doubled. This raised a red flag about the potential problem of rapid spread of HIV in South Africa's poor communities.

Quarraisha Abdool Karim's data also showed that infection rates were much higher among women than men and that, disturbingly, young women were getting infected in their teenage years, while men tended to become infected in their late 20s. She realised, that this suggested that HIV was spreading between older men and younger women, clearly identifying teenage girls as a particularly vulnerable risk group for HIV.

STEERING SA'S AIDS RESPONSE

In the early 1990s, Abdool Karim convened a group of scientists working on HIV in Durban to meet once a month and discuss their work. News of the group spread to rural clinicians, and it eventually became the KwaZulu-Natal AIDS Forum. Community groups attended the meetings to talk about challenges they were facing. She also served on the first National AIDS Co-ordinating Committee of South Africa, which was tasked with writing the country's first national AIDS plan.

In 1994, she was asked by the Mandela government to establish and lead the National AIDS Programme. With antiretroviral treatment using combination drugs still to be discovered and South Africa experiencing the early stages of an asymptomatic HIV epidemic, the programmes she oversaw focused on prevention and education. She stayed in the post for two years, during which she had to navigate the government's blunder in spending

over R14 million on an ill-judged play called *Sarafina II*, which critics denounced as inappropriate and unclear.

In 1997, Abdool Karim returned to the MRC as a researcher and started to undertake clinical trials testing novel prevention interventions. At the same time she co-ordinated the Columbia University – Southern African Fogarty AIDS Training Programme, which trained scientists in southern Africa to respond to the HIV and TB epidemics. By this time, she was serving on the governing council of the International AIDS Society (IAS), which organised annual AIDS conferences around the world. By the mid-to-late 1990s the IAS wanted to hold a conference in the developing world, which was emerging as the new battleground against the virus. With the help of South Africa's government and other scientists, she was able to secure the 2000 International AIDS Conference for her home town, Durban.

The injustice of the lack of access to antiretrovirals for millions of poor HIV-positive Africans was a major focus of the Durban conference, and the conference succeeded in bringing global attention to this challenge.

Abdool Karim earned her PhD from the University of Natal in 2000. Her thesis was on women and AIDS – epidemiology and gender barriers to prevention in KwaZulu-Natal. In 2001, she began working with her husband on an application to create a new research centre focusing on HIV/AIDS and tuberculosis (TB) in South Africa. The resulting Centre for the AIDS Programme of Research in South Africa (CAPRISA) was funded by the National Institutes of Health in the USA to the tune of R140 million over five years. It was a joint initiative between the Durban-based Nelson R Mandela Medical School, the National Institute for Communicable Diseases (NICD) in Johannesburg, the University of Cape Town, the University of the Western Cape, and Columbia University in the USA.

CAPRISA's flagship research programmes focused on the tuberculosis/HIV co-epidemic and acute HIV infection, as well as on HIV epidemiology and prevention. Abdool Karim wanted the research to have a strong community element. She and her husband were invited to partner with a rural community outside Durban, which had been hard hit by HIV and was look-

ing for help to deal with the scourge. The CAPRISA Vulindlela Clinic was established as a field research clinic in this community in 2002.

THE HUNT FOR A MICROBICIDE

The CAPRISA Vulindlela Clinic was one of two sites where CAPRISA tested a vaginal microbicide that could be used by women to prevent HIV infection. The gel contained the antiretroviral drug tenofovir – the first time an antiretroviral drug had been used as the active ingredient in a microbicide.

Abdool Karim had become determined to find a woman-controlled HIV-protection technology while working with sex workers in the early 90s. She offered HIV testing to sex workers from the Natal Midlands and found that about 60% of them were already infected with HIV. They said they could not insist on condoms and, as sex was their livelihood, abstinence was not an option for them. “They asked me if there was something they could use to protect themselves,” she says.

In the years that followed, Abdool Karim worked on several experimental microbicides. But none of them protected women in the trials against infection. However, the CAPRISA 004 tenofovir gel trial, which ran from May 2007 through March 2010, would change all that.

Women in the trial were instructed to insert the gel before and after they had sex. The results – a 39% reduction of HIV infection in the group receiving the active gel – obtained a standing ovation when it was announced at the 2010 International AIDS Conference in Vienna. The finding was hailed as a milestone in AIDS research. However, later studies of the same gel in other health care settings or using a daily dosing strategy did not show efficacy because of low levels of adherence.

Nevertheless, the CAPRISA 004 trial gave a new lease of life to the microbicide research field, and to HIV prevention more generally. New woman-controlled prevention methods are being tested in CAPRISA's clinics,

including a vaginal ring containing the antiretroviral dapivirine and an injection of a new class of ARV drug called integrase inhibitors. These might be more user-friendly prevention methods for some women, given that they could provide protection for a month or longer.

Abdool Karim is also leading studies to see whether social incentives can help curb HIV-infection rates, especially among teenagers in KwaZulu-Natal. She is the principal investigator on a study to determine whether cash incentives can help improve the outcomes of school-based HIV-prevention programmes. Another of her studies has looked at whether voluntary male circumcision programmes, which have been proven to reduce HIV-infection rates, can be rolled out through schools, and defining the provision of sexual reproductive health services to school-going adolescents and young women.

She serves on a range of international organisations and is a member of numerous academic bodies, including the US National Academy of Medicine (previously called the Institute of Medicine). She holds an A-rating from the South African National Research Foundation (NRF).

A proud working mother, she sees her three children as part of her personal accomplishments. She and her husband have shared childcare duties, and avoid travelling at the same time to maintain stability and continuity at home. She used to block off the hours between 5pm and 8.30pm to give her children baths and help them with their homework and read to them – something she does not have to do anymore, now that the children are all old enough to look after themselves. But this time remains precious for the family to get together at the end of the day.

Says Abdool Karim: “We have made huge progress in our response to the HIV epidemic to the point where the possibility of epidemic control is possible. However, we have a long way to go in empowering young women to protect themselves from HIV and until then we have to soldier on. Failure to prevent HIV infection in young women in Africa is not an option.”

| SALIM S ABDOOL KARIM |

TOP THREE AWARDS

- African Union's Kwame Nkrumah Continental Scientific Award, 2015
- President's Award for Outstanding Achievement in World Health (to the CAPRISA 004 Leadership Team) from the Drug Information Association, 2011
- Science-for-Society Gold Medal Award from the Academy of Science of South Africa (ASSAf), 2011

DEFINING MOMENT

My plenary address in 2015 at the General Assembly of the African Union in Addis Ababa on the critical importance of science for Africa's prosperity.

WHAT PEOPLE DO NOT KNOW

I was a disco DJ at *Disco Inferno* for a few years while I was a medical student in the late-1970s.



THE CLINICAL RESEARCH CRUSADER

Salim Abdool Karim is a revolutionary in everything he does, be it opposing apartheid rule, challenging AIDS denialists, or revamping South Africa's medical research funding. Along the way, he has ruffled some feathers. But 'Slim', as he is known to most, gets away with it because his actions are designed for the greater good, and because he is a master at what he does.

Today, he is one of South Africa's best-known AIDS scientists. He is the founding Director of the Centre for the AIDS Programme of Research in South Africa (CAPRISA), a 150 million Rand per year multi-institutional research centre headquartered at the University of KwaZulu-Natal's (UKZN) Nelson R Mandela Medical School.

In partnership with his wife, Quarraisha, an equally accomplished HIV researcher, he has played a key role in turning the focus of the world onto the devastating HIV and tuberculosis epidemics ravaging South Africa, and in particular his home province of KwaZulu-Natal.

"We do science for the betterment of society," he says. "Our ambition is to undertake globally relevant and locally responsive research that can make a real difference to people's lives."

EDUCATION AND EARLY LIFE

The son of a poor factory worker, Salim Abdool Karim grew up in central Durban. In 1970, when he was ten years old, he and his family were forced to move from their home in the city centre to the newly developed Chatsworth township that had been designated for Indians under the Group Areas Act.

He got his nickname 'Slim' (clever in Afrikaans) at the Gandhi Desai High School in the Durban city centre, to which he continued to commute even after his family's relocation. As a young man he played an active part in the anti-apartheid movement although, as an avid follower of Mahatma Gandhi, he never took up arms in the struggle.

His first choice for university study was engineering. Unable to secure a scholarship for engineering, he opted for medicine when he secured two scholarships for medical studies instead. He obtained his medical degree from the University of Natal medical school in 1983. It was a hotbed of activism at the time as the only medical school in the country that allowed students who were not white. As a medical student he was a delegate at the launch of the United Democratic Front (UDF) in Mitchell's Plain, coming back to Durban an even more inspired anti-apartheid activist.

He was an ambitious student, keen to explore new ideas and opportunities. He published his first research paper with his mentor, Professor Jerry Coovadia, in the *International Journal of Health Services* as a third-year medical student. After graduating, he did his internship at the King Edward VIII Hospital in downtown Durban and registered as a medical professional in 1985. He simultaneously completed a diploma in computer science through the University of South Africa, to satiate his thirst for all things technological.

In 1987, he obtained a fellowship to study epidemiology at Columbia University in New York. Less than a week before his departure, he met his wife-to-be, Quarraisha. Later that year, he returned home to get married and the two went together to study at Columbia University after their wedding.

AN UP-AND-COMING AIDS RESEARCHER

Buoyed by his learning experiences in New York, which was in the throes of the AIDS epidemic at the time, Abdool Karim returned to South Africa with his wife in late 1988. He took a job as Registrar in public health medicine at the Medical School in Durban to complete his specialist training. In 1993, he joined the South African Medical Research Council (MRC) as the Director of its Centre for Epidemiological Research.

Over the next few years he pioneered the establishment of several research centres in South Africa based on large grants from international sources. In 1997, he led a consortium that won funding from the Wellcome Trust in the UK to set up the Africa Centre for Population Studies and Re-

productive Health in northern KwaZulu-Natal. He also secured a substantial grant from the US National Institutes for Health (NIH) to become part of HIVNET, an international network that conducted HIV prevention trials.

When the HIVNET grant came to an end after two years, he secured two new grants from the NIH: One to establish a HIV prevention trials unit, and another to create a HIV vaccine trials unit at the MRC. These grants were trailblazers, as the primary applicant was the MRC, rather than a US institution as was the norm for NIH research grants at the time.

The research funding that Abdool Karim acquired from international research agencies for his home institution, dwarfed what was available within South Africa at the time. Applying for and managing these research centres gave him valuable experience that he would later put into bringing an even bigger and more multi-faceted grant into South Africa to create CAPRISA.

In 2000, Abdool Karim was the Scientific Programme Chair of the International AIDS Conference in Durban. It was the first such conference to take place in a developing country. At this time, South Africa's government had become notorious for denying the link between HIV and AIDS, and he was one of the scientists who opposed the AIDS denialists, whom he saw as being responsible for the loss of thousands of South African lives.

In 2001, Abdool Karim was recruited from the MRC to become Deputy Vice-Chancellor for Research at the University of Natal (which, in 2004, formed part of the new University of KwaZulu-Natal).

Shortly after arriving at the university he heard that the NIH was offering a new funding opportunity that would allow groups of developing country researchers to set up world-class medical research centres targeting HIV in the communities most affected by the disease.

A NEW AIDS CENTRE IS BORN

Slim and Quarraisha formed a consortium with colleagues from the NICD in Johannesburg, the University of Cape Town, the University of the Western

Cape and Columbia University, and applied for the grant. They were successful in winning over US\$12 million to be paid out over five years, and in 2002, CAPRISA was born.

From the outset CAPRISA's primary research priorities were to study acute HIV infection, with a view to developing insights for vaccines, as well as how to best treat patients with HIV and tuberculosis, the dual epidemics ravaging Africa. The centre established clinical research facilities at an urban TB clinic, as well as in the rural village Vulindlela, an hour's drive from Durban.

CAPRISA's scientific achievements have included developing a best-practice treatment approach for TB and HIV co-infection, which has been adopted by the World Health Organisation. It has also pushed the envelope in producing HIV prevention technologies that can be used and controlled by women.

CAPRISA's famous 004 trial found that a vaginal gel containing the antiretroviral tenofovir inserted before and after sex reduced women's risk of HIV infection by 39%, with an even higher rate of protection if women adhered closely to the dosing regimen. The gel was also found to protect women against infection with Herpes Simplex type-2, a virus that commonly causes genital ulcers.

Quarraisha and Slim jointly presented the CAPRISA 004 results at the International AIDS Conference in Vienna, in July 2010. It was hailed as a landmark study – the first evidence that antiretrovirals can prevent sexual transmission of HIV and the first microbicide trial to ever show a positive result. Unfortunately, later studies of the gel found that in a clinical setting, women seemed unwilling to use the gel as directed, reducing its efficacy and usefulness in real-world applications.

The disappointing tenofovir gel results in recent clinical studies did not discourage him. He stepped forward with new energy to develop long-acting HIV prevention approaches that can circumvent the adherence challenges experienced by women. The field of HIV prevention needs alternatives, he says. There won't be a one-size-fits-all solution.

Abdool Karim and his colleagues in CAPRISA's acute infection study have identified a highly active broadly neutralising antibody, able to kill a wide range of HIV strains. The antibody was isolated from a woman in KwaZulu-Natal, whose body had developed it to cope with her HIV infection. The antibody has been successfully tested in monkeys and is now being manufactured for human trials as a 3-monthly injection to protect women from acquiring HIV. If it works it will be an amazing discovery to come out of South Africa.

Says Abdool Karim: "What makes CAPRISA different is the way we work with the community and try to impact their lives. For us, the research is more than test tubes and Petri dishes; it's about the people."

There are also many challenges remaining in understanding TB and HIV, he says. He was one of the three-person team that convinced the Howard Hughes Medical Institute (HHMI) to base its first research centre outside the United States (US) in South Africa, leading in 2008 to the creation of the KwaZulu-Natal Research Institute for Tuberculosis and HIV (K-RITH), which carries out basic research on TB and HIV. K-RITH and CAPRISA now share a world-class research building on the UKZN medical school campus.

REVITALISING THE MRC

In April 2012, he was appointed President of the MRC after repeated attempts by the MRC's Board had failed to fill the post. He accepted it as a part-time job on the request of Aaron Motsoaledi, the country's health Minister, who was Abdool Karim's classmate in medical school. The MRC was in bad shape at the time. Its many intramural research units were eating up most of its research funding, with little left for the country's badly stretched medical schools. A report by ASSAf in 2009 had found clinical research to be in dire straits in South Africa.

During his two years as the council's head, he overhauled its research priorities, slimming them down to match South Africa's ten major killers, including HIV, TB and heart disease. He also axed a quarter of the council's staff and closed more than half of its 27 intramural units, leaving only 11

behind. Such major change could have made him unpopular, had he not proceeded to fill the council's coffers with new funding.

First, he secured R340 million from Treasury's Economic Competitiveness Fund to fund 'flagship projects' addressing South Africa's key health problems. Having had great successes in winning large grants from the NIH as a researcher, he then chose to employ this skill and his international linkages for the common good of South African research. At the end of 2013, just before Abdool Karim left the council, the MRC launched a US\$40 million (>half a billion rands) five-year programme jointly with the NIH for research on tuberculosis, HIV and HIV-related cancers.

Another partnership, with the Bill & Melinda Gates Foundation and the South African government, resulted in a three-year research fund, worth close to R1 billion, for AIDS/TB diagnostics, treatments, vaccines and other technologies.

After leaving the MRC, he went back to being scientific Director of CAPRISA. He has held a number of international positions as well. Since 2000, he has been a Professor of Epidemiology at Columbia University and an adjunct Professor of Medicine at Cornell University. Columbia recently appointed him to a newly endowed Global Health Professorship named after CAPRISA. In 2013, he was asked to Chair a new Joint United Nations Programme on HIV/AIDS (UNAIDS) Scientific Expert Panel. CAPRISA is also a long-standing UNAIDS Collaborating Centre on HIV prevention research and policy, meaning it advises the international body on scientific issues related to HIV prevention.

Abdool Karim sports a relentlessly positive view of the role that South Africa's scientists can play in the country's future. "Armed with a fistful of original ideas, entrepreneurial spirit, and a brave willingness to explore new terrain, the country's scientists are well placed to help the nation realise the South African dream: Sustainable development, economic prosperity and healthy lives. This can be achieved with active support for both education and research in the hallowed halls of academia, as this is critical to sowing the seeds of tomorrow's success on the path to greatness," he says.

| JILL ADLER |

TOP THREE AWARDS

- ICMI Hans Freudenthal Medal, 2015
- Svend Pedersen Lecture Award, Department of Mathematics and Science Education, University of Stockholm, 2015
- ASSAf Science-for-Society Gold Medal, 2012

DEFINING MOMENT

Academically speaking in 1988, when my Masters research was published in *Educational Studies in Mathematics*, the leading mathematics education journal in the field – this was catalytic in shifting me into an academic career.

WHAT PEOPLE DO NOT KNOW

I was an avid netball player at school and my piano was my best friend.



THE ENGAGED SCHOLAR

Most academics spend much of their time teaching. But few South African high-school teachers end up becoming world-renowned researchers with an A-rating from the National Research Foundation. Yet, this is what Professor Jill Adler has done. A teacher by training, an activist at heart, she has bucked many trends to become one of the world's leading experts in mathematics education research.

Throughout her career, her focus has been on serving society. The idea of academic achievement as an end in itself does not appeal to her one bit. She makes sure the research she does speaks to teaching practice, and also that problems in teaching practice inform her research.

Her work has laid the foundations for a growing community of South African and southern African scholars working in the field of school mathematics education. Her 2001 book, *Teaching Mathematics in Multilingual Classrooms* did not only address a key challenge in South African schools, but has also had a profound influence on international research in the field of mathematics education.

She currently holds the SARChI – First Rand Foundation (FRF) Chair of Mathematics Education at the University of the Witwatersrand (Wits), and simultaneously held the Chair of Mathematics Education at Kings College, London in the UK from 2007 until 2014. She is a prime example of a South African researcher doing research that is at the same time globally relevant and responding to local societal needs.

EARLY YEARS AND TEACHING

Jillian Beryl Adler (née Smidt) never planned to become a researcher. She was born in 1951 in Johannesburg. At school, she showed an aptitude for mathematics. She studied mathematics and psychology at Wits.

Her bachelor's degree was interrupted in its first year by a year in the USA on an American Field Scholarship. She spent her time in Seattle in Wash-

ington State and it had a profound impact on her political worldview. The US at the time was seeing the peak of protests against the Vietnam War. It was in this volatile atmosphere that Adler became truly aware of the despicable politics happening in her own country. Not having grown up in a political family, she had been relatively protected from her own country's political realities. When she came back to South Africa, she started to get involved in the struggle against apartheid.

After graduating from Wits in 1972 she spent a year at the University of Cape Town studying for her teaching qualifications. It was a straightforward choice. "I always thought that my professional career should be in teaching," she says. In Cape Town she and other trainee teachers resolved to go and work in so-called coloured or black schools.

Adler ended up spending two years teaching at Harold Cressy High School in the District Six area of Cape Town. The school was a hotbed of opposition to apartheid, and one of its most famous alumni is Trevor Manuel, South Africa's finance minister from 1996 until 2009. In 2014, the school was declared a provincial heritage site.

In January 1976, Adler went backpacking around the US and Europe, returning to South Africa in August that year. Needing to work immediately she took up a teaching job at King David High School in Victory Park in Johannesburg for the final term of the year. She did not last long at the school. While she had all intentions of returning to Cape Town, in that short period in Johannesburg, she met her husband, and has lived and worked in Johannesburg ever since.

WAKING UP TO ACADEMICS

Adler got a job working for the South African Committee for Higher Education (SACHED). She worked on distance education, especially contributing to the mathematics content for an educational supplement to *Weekend World*, South Africa's first 'black' newspaper. However, in 1977 the apartheid government banned *Weekend World* as well as the whole leadership of SACHED, including one of the directors who would later become Adler's

brother-in-law. The junior staff of SACHED were promoted and Adler suddenly found herself Head of its Research and Development Department.

Adler's interest in academic work was kindled during her time at SACHED. Through SACHED she identified a group of adults who had used her teaching materials to learn mathematics. They became the subject of her Masters thesis, in which she explored using newspapers as a medium for adult distance learning. She obtained her Masters of education with distinction in 1985 from the University of the Witwatersrand (Wits).

Adler then moved back into full-time employment, and was attracted by a job she saw advertised at the Johannesburg College of Education involving training primary school mathematics teachers. She applied, despite having limited primary mathematics teaching experience and to her surprise she got the job, which she began in 1986. In 1989, she moved to the Wits Department of Education as a lecturer and in 1991 embarked on a PhD.

Adler based all her academic work on what she calls problems of practice. Her PhD looked at teaching and learning mathematics in multilingual classrooms. By the time she was capped, in 1996, she had taken a leading role in pioneering the Further Diploma in Education (FDE) programme at Wits. The FDE was designed to enable disadvantaged teachers to upgrade their qualifications and at Wits the programme was focused on mathematics, science and English language teaching.

In 1997, Wits advertised for an academic chair in mathematics education, located in the Mathematics Department in the Faculty of Science. Adler applied and was successful, despite having only obtained her PhD the previous year. "I know I was given it on promise, rather than on what I had already achieved in research terms," she says. In this new position, she used the funds made available for the chair to set up a PhD programme, so that she could 'reproduce' herself. She took on a group of PhD students and supported them to develop their own area of interest, though within her broad orientation to learning as a social enterprise.

Adler's book *Teaching Mathematics in Multilingual Classrooms* was published in 2001 to great national and international acclaim. Her work on multilingual learning and teaching was pioneering. At a time when communication was being emphasised as central to learning mathematics, little of the research included in its scope what this meant in a multilingual context like South Africa. Over time, Adler also came to epitomise the idea of the 'engaged scholar', working at the cutting edge of her field while responding to local and regional needs in education.

FURTHER ACADEMIC DEVELOPMENT

In 2002, the funding for Adler's chair ended, and she became Professor of Mathematics Education, and at the same time moved to the Wits School of Education in the Faculty of Humanities. Prior to this, and while still in the Faculty of Science, Adler led the development of a new Honours programme, BSc Hons in Science Education, a programme that provided access to postgraduate study for graduates from the FDE, as well as filling a gap between the existing BEd Hons and pure mathematics (or science) Hons degrees. It was clear at that time that there were many practising mathematics and science teachers who would benefit most from an Honours programme that provided for both further study of mathematics (or physics, chemistry, biology) and of education, and critically that the mathematics or science in this study was appropriate for those in the profession of teaching. The BSc Hons in Science (and mathematics) Education has produced numerous graduates, some of whom have proceeded through Masters and PhD study, and others of whom have taken up leadership roles in their schools or in the provincial and national departments.

It was during this period that Adler, with others, raised funds for and then launched the Marang Centre for Mathematics and Science Education, a centre she has directed at various times. Marang celebrated its 10th anniversary in 2015, and over the decade has become known as a leader in postgraduate mathematics and science education in the country and the region.

In 2006, Adler became aware of the Chair of Mathematics at Kings College, London, and was encouraged to apply. At that point, she says, she was looking for a change in scenery, though when the position was offered to her, she negotiated for a joint position, half time, so that she kept a foot in her faculty at Wits. Between 2007 and 2009 she spent periods of time in London, while continuing her supervision, some teaching and research at home. "It was very good for me to get my head into another place," she says. In 2009, when the FRF Chair was advertised, she reduced her time in the UK to a 20% position to be able to take up the Wits Chair full time.

INTERNATIONAL ACCLAIM

She has attracted a number of distinctions and awards. Adler has also received international acclaim. In 2015 she was honoured with the Freudenthal medal by the International Commission for Mathematics Instruction (ICMI) "in recognition of her outstanding research programme dedicated to improving the teaching and learning of mathematics in South Africa – from her 1990s ground-breaking, socio-cultural research on the inherent dilemmas of teaching mathematics in multilingual classrooms through to her subsequent focus on problems related to mathematical knowledge for teaching and mathematics teacher professional development" and the Svend Pedersen Lecture Award, issued by the Department of Mathematics and Science Education at the University of Stockholm, Sweden, for research that had made a significant and lasting contribution.

Throughout Adler's career her family has always come first. Both her children are married and she talks passionately and proudly about their role and engagement as a family in social change in South Africa.

The funding for the FRF-NRF chair was renewed in 2015 until 2019, and this is now a Tier 1 Chair within the SARChI stable at the NRF. It is "a good way to end a research career," she says.

To quieten her mind she plays Sudoku, and admits that she is a bit obsessed with the Japanese numbers game. She also reads what she calls "rubbish novels" – detective stories, crime fiction. She has joined a walking club and enjoys spending time with her grandsons.

She wants to move away from full-time work in the not too distant future, as she reaches retirement age. She says: "I'm clear that I can't keep doing this level of work forever. I want less stress and more time with my family!"



| PATRICIA BERJAK |

TOP THREE AWARDS

- Department of Science and Technology Distinguished Woman Scientist Award, 2004
- National Order of Mapungubwe (Silver), 2006
- National Research Foundation President's Lifetime Achiever Award, 2008

DEFINING MOMENT

Probably when she realised that analysing urine in test tubes was not exciting science and she moved into seed science.

WHAT PEOPLE DO NOT KNOW

She would not get going in the morning until she had completed the Word Game in the morning newspaper. Tea must be made with actively boiling water. She devoured detective novels. There was always a bottle of 'cold tea' in her desk drawer for after-hours discussions.



DOYENNE OF SEEDS

Professor Patricia Berjak was born in Johannesburg on 29 December, 1939. After attaining her BSc (Hons) *cum laude* in biochemistry from the University of the Witwatersrand (Wits) in 1962, Berjak moved to Natal, where she spent a year as a teacher before taking up a post at the University of Natal, now known as the University of KwaZulu-Natal (UKZN), an institution which would eventually become her academic home, as a research assistant and temporary lecturer in the Department of Physiology. She went on to complete her MSc in mammalian physiology in 1966.

However, while at the University of Natal studying under the biologist-tutor Trevor Villiers and working as a junior lecturer in plant biology, Berjak was introduced to the domain of seeds and electron microscopy. Here she found her true vocation as a cell biologist. In 1969, she completed her PhD in seed biology, examining the ageing of stored maize seeds. While much of her later research focused on recalcitrant (desiccation-sensitive) seeds, her doctoral thesis investigated orthodox (desiccation-tolerant) maize seeds, a staple food in much of Africa. These degrade when stored under warm, relatively high humidity conditions that also encourage fatal fungal growth in the seeds. Berjak's doctoral research discovered the means to significantly reduce fungal growth in maize seeds, where the growth of mycoflora is associated with poor storage conditions. This allows maize seeds to be stored for substantially longer periods, which in turn contributes to increased food security.

Her findings went on to form a major chapter in a definitive work on the subject by EH Roberts, *Seed Viability*, as well as five papers from her doctoral thesis being published internationally.

This was followed by a three-year period in the United Kingdom, where she held the post of experimental officer with lecturing duties at the University of Leeds, returning to South Africa in 1973 in the capacity of senior lecturer in biological sciences at the University of Natal. She was appointed as full Professor in 1985, periodically serving as Acting Head of department, as well as in the capacity of the Head of the Division of Biological Sciences.

She was later appointed as the Deputy Head of School, and in 2005 was made Professor Emeritus.

Her major research focus was in the field of non-orthodox seed biology, particularly in the area of seed desiccation sensitivity (or 'recalcitrance'). Recalcitrant seeds, unlike orthodox seeds, contain moisture and are destroyed when they dry out. Some of these recalcitrant species are essential food and traditional medicinal sources in Africa, with some examples of these plants including mangoes, litchis, avocados, coconuts, cocoa trees and rubber trees. Orthodox seeds, for example maize seeds, are dry and can be stored for long periods before supplying water which allows them to germinate and grow into mature plants. Recalcitrance diminishes the storage 'lifespan' of the seeds of a significant number of seed-bearing species. Throughout her illustrious career, Berjak would investigate the range of factors associated with the storage of such seeds: the optimal conditions for this, the germplasm cryopreservation of species producing these seeds and the minimisation of damage to seeds to which conservation techniques have been applied. She was also pivotal to the development of synthetic seeds (synseeds) as a means for short-term storage and distribution of axes recovered from cryopreservation. Her work often bisected disciplines, ranging from the molecular to the ecological spheres in order to enrich understanding of the phenomenon of seed recalcitrance.

The ultimate goal of this research was the enhancement of the storage potential of such seeds with beneficial applications in the fields of biodiversity as well as food security, a critical area of study in the developing world. This was accomplished through in-depth investigations relating to the cell biology and manipulation of these species for optimal germplasm conservation and subsequent distribution of recalcitrant seeds; the manner in which these seeds would respond to stress; problems in the propagation and germplasm conservation of heavily-exploited African plants; and the contribution of associated mycoflora (fungi) to the reduced storage lifespan of these seeds. Part of this was the exploration of seed-fungal relationships in the storage of orthodox seeds, including seed pathology, fungal transmission and attempts to eradicate the mycoflora. The research on non-orthodox seeds included extensive work directed to the conservation,

particularly by cryopreservation, of the genetic factors of species producing recalcitrant seeds which makes them inherently non-storable; this work reduces the risks of extinction of these plants.

Armed with the knowledge gained through these endeavours, Berjak's research has been instrumental in refining storage practices of seeds, thus diminishing the risks posed by fungi in the deterioration of these seeds, and developing the application of cryobiology principles to the long-term conservation of the plant species that produce recalcitrant seeds.

ACROSS BORDERS

Over the course of her career, Berjak was involved in numerous research projects and collaborations internationally, as well as within South Africa. She was responsible for the organisation and supervision of the collaborative investigations of two international working groups for the International Seed Testing Association, as well as collaborating with the International Board for Plant Genetic Resources (IBPGR), later Bioversity International, for the development of storage methods for recalcitrant germplasm.

During a sabbatical period in the early 1980s, she was able to work in the laboratory of Professor JS Clegg at the University of Miami. At the time, Professor Clegg was exploring methods to characterise the states of water in animal cells and tissues. This coincided with Berjak's aims to apply similar methods to the study of water in desiccation-sensitive seed material, an objective she was unable to realise locally due to the limited facilities at her disposal in Durban at that point. However, later she was invited to the United States Department of Agriculture – Agricultural Research Service (USDA-ARS) National Seed Storage Laboratory (NSSL, now known as the USDA-ARS National Centre for Genetic Resources Preservation), where she was able to pursue these investigations during several separate visits alongside Dr C Walters (formerly Vertucci). Thereafter, she was able to found a complementary biophysics laboratory in Durban, which IPGRI (now Bioversity International) identified as an international centre of excellence.

This collaborative work yielded several publications and presentations at conferences, abroad as well as locally. More importantly, Berjak wrote,

those investigations furthered understanding of the thermal behaviour of water in desiccation-sensitive seeds which, in turn, could facilitate recalcitrant germplasm cryopreservation on a predictive basis.

She entered into numerous research collaborations spanning a number of continents, investigating the responses of seeds from a diverse range of climates, including wild rice in the USA, *Picea* in Canada, pine in South Africa, and desert plants in Namibia, amongst others.

In 2000, Berjak spent a productive period with colleagues in the Applied Plant Physiology Department at the *Université Pierre et Marie Curie*, Paris, where collaborative efforts were focused on the unusual phenomenon of the comparative desiccation tolerance of wheat coleoptiles. Berjak's microscopical expertise (contributing to a paper in *Physiologia Plantarum*) indicated that intracellular compensation and repair mechanisms, which are unexpected in desiccation tolerance in higher plants, might be the basis of the phenomenon.

In mid-2005, a three-year award was received from the UK government's Department for Environment Food & Rural Affairs (DEFRA) Darwin Initiative for a cryoconservation centre of excellence (CCESSA), in conjunction with the Millennium Seed Bank (MSB). This was coordinated by the Royal Botanic Gardens, Kew with the ultimate objective of establishing cryobanking for plant genetic resources for sub-Saharan Africa.

More recently, Berjak was a major driver in initiating networking in the Southern African Development Community (SADC) region aimed at excellence in seed and plant germplasm banking in line with objectives embodied in the African Union/New Partnership for Africa's Development (AU/NEPAD) Consolidated Plan of Action for Science and Technology (2005). She was also involved in plans for establishing a consolidated banking system for plant genetic resources in conjunction with the existing Wildlife Biological Resources Centre/BioBankSA at the National Zoological Gardens (NZG) based in Pretoria. The prototype of this plan, presented in the UK at the Society for Low-temperature Biology's meeting, Cryo2010, resulted in the South African 'cryo-team' (UKZN and Wits) being invited as members of the UNESCO Chair in Cryobiology.

Not only a prolific researcher, Berjak was known as an exacting mentor to her students, and took pride in the part she played in building the academic capacity of the country, across cultural and gender boundaries. She supervised 42 students pursuing MSc degrees and 18 PhD students to completion, as well as hosting numerous postdoctoral associates from abroad. Several of her students went on to receive prestigious awards and followed successful academic careers, and she maintained close ties with past students, most notably Jill Farrant from the University of Cape Town (UCT) and David Mycock from Wits, with whom she continued to collaborate on research projects. In addition to this, she published extensively in international journals and monographs, also acting as a referee and serving on the editorial board for a number of these, as well as frequently presenting at international conferences.

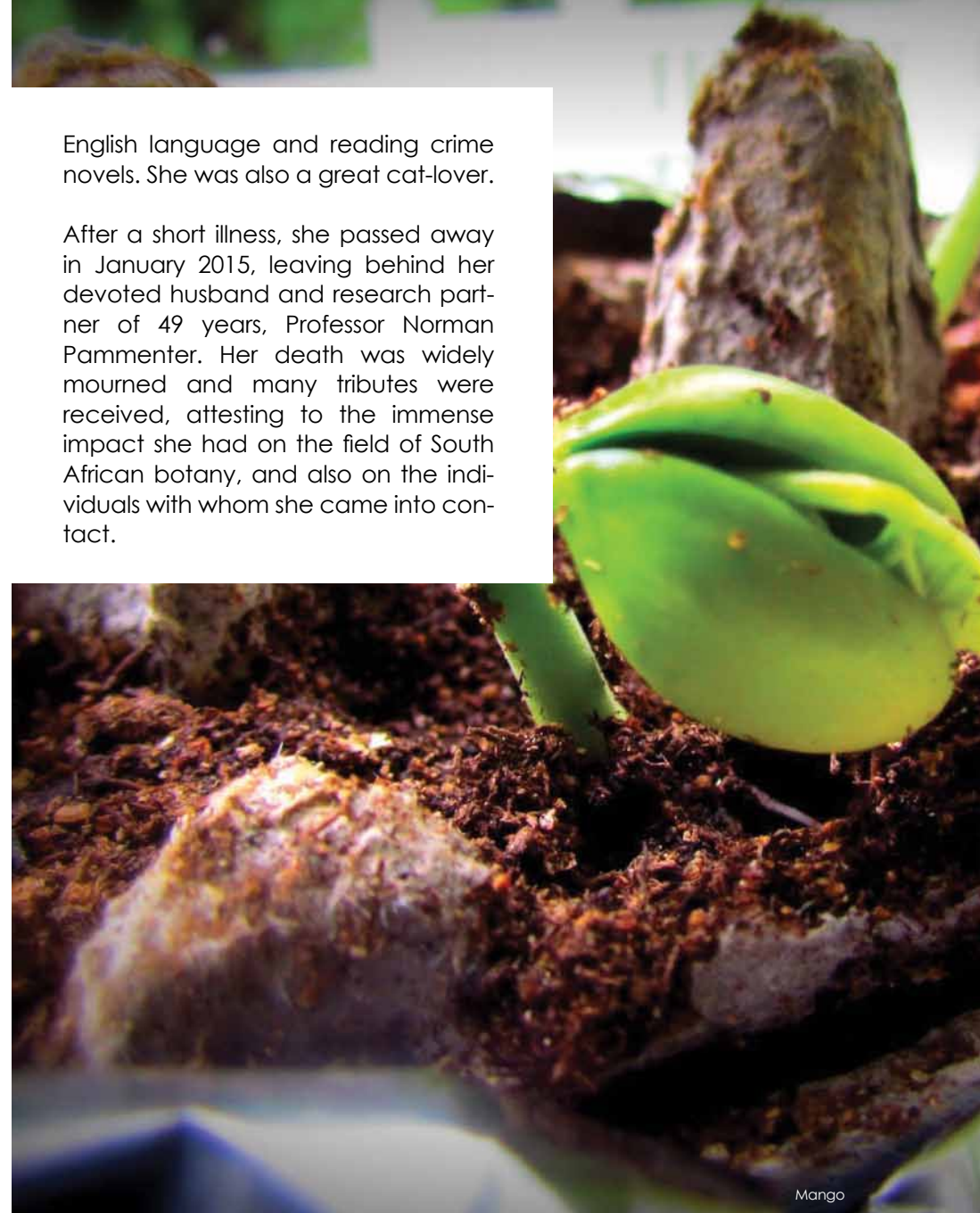
Berjak was an active member of the academic community at the University of Natal, serving on the staff club in a variety of roles, as well as on other university committees, as well as liaising with the Natal Education Board in the development of the biology syllabus. She was also a participant in numerous other committees, national and international, such as the International Seed Testing Association (ISTA), the Electron Microscope Society of Southern Africa (EMSSA), and the International Society for Seed Science (ISSS), of which she served as President between 2008 and 2011, and several working groups in South Africa. As an active conservationist, she was involved in activities coordinated by the National Parks Board, and the Durban Botanic Gardens, amongst others, and served as a Board Member of the United Nations University Institute for Natural Resources in Africa from 1999 until 2008.

She served as a Member of the ASSAf Council from 2006 onwards, as well as holding the position of Vice-President.

Apart from her academic life, Berjak was a dynamic individual with a broad spectrum of interests. She was an active member of the Red Cross ambulance service in the 1960s, and was a Gold Medallist of the South African Red Cross Society. She held a private pilot's license and enjoyed aerobatics, cooking, ballroom dancing, bridge, classic cars, photography, the

English language and reading crime novels. She was also a great cat-lover.

After a short illness, she passed away in January 2015, leaving behind her devoted husband and research partner of 49 years, Professor Norman Pammenter. Her death was widely mourned and many tributes were received, attesting to the immense impact she had on the field of South African botany, and also on the individuals with whom she came into contact.



Mango

| THOMAS BOTHWELL |

TOP THREE AWARDS

- Gold Medal of the South African Medical Research Council
- John FW Herschel Medal of the Royal Society of South Africa, 1993
- Science-for-Society Gold Medal of the Academy of Science of South Africa, 2005

DEFINING MOMENT

The publication of my first scientific article in an international journal (*Journal of Laboratory and Clinical Medicine*) in 1951.



ACROSS MEDICAL FRONTIERS

The son of Scottish immigrants to South Africa, Thomas Hamilton Bothwell was born on 27 February 1926 in Johannesburg. Having received a scholarship to attend St John's College, he matriculated first class in 1941. From here, he went on to attend the University of the Witwatersrand (Wits), obtaining a Bachelor of Medicine and Bachelor of Surgery in 1948. He received the Bronze Medal of the Southern Transvaal Branch of the Medical Association of South Africa for the most distinguished medical graduate of the year, as well as being awarded the Medical Graduates Association Prize for the best final-year student in Medicine.

Bothwell later explained, in his reflections on his career, that this period was one of crossing numerous frontiers in medical training in the country, for the first time establishing a formalised clinical medical faculty with dedicated researchers – prior to this, medical students were largely trained by practising medical doctors contracted to the university. During this time he was taught by, among others, Professor William Craib, a pioneer of electrocardiography, and Professor Raymond Dart, best known for uncovering the Taung skull. In his class was another legend in the making, Sydney Brenner, who was destined for enormous success in the field of DNA research.

Bothwell's own research would further develop findings made by Archie Strachan, his Professor of pathology, whose MD thesis documented the high prevalence of iron overload in the black population of South Africa. Bothwell's interest in haematological research began in 1948 when, as a young intern, he encountered a patient admitted with cardiac symptoms, hepatomegaly and hypogonadism. This was indicative of idiopathic haemochromatosis, a genetic disorder in which iron accumulates in the body leading to overload of the mineral. With little known about iron balance at the time, Bothwell undertook research to establish links between idiopathic haemochromatosis and abnormally high levels of iron absorption in the gut, using radioactive iron to measure the absorption of his patient against a control subject, comparing intake of iron to the levels excreted in stool samples. (He recounts the humorous aspect of this study, when other workers in the building complained of the smell in the corridors.

Happily they never succeeded in hunting down the source thereof.) He found that his patient showed significantly higher levels of absorption when contrasted to the control subject. The study of the various facets of this problem, and related conditions, formed the basis of Bothwell's lengthy and illustrious research career.

From 1954 to 1957, Bothwell spent some time furthering his research career abroad – first attending Oxford on a Nuffield Fellowship, and then continuing his research on iron metabolism at the University of Washington, Seattle. This time would prove a turning point in his career, developing lifelong research partnerships. Working in the Nuffield laboratory at Oxford was a worthwhile experience for the young Bothwell, as he expanded his knowledge of laboratory techniques while conducting numerous ferrokinetic measurements in patients with a variety of blood diseases. In addition, he developed a new method for measuring iron in blood serum, which was published in the *Biochemical Journal* and became the standard for a number of years. Indeed, there were times where Bothwell was not only researcher, but research subject. One experiment involved his taking blood samples from himself in his room at Balliol College throughout the night. However, this proved more difficult than anticipated and the next morning the room attendant was met with blood-splattered sheets and a very embarrassed young research worker.

Whilst attending a congress at the Sorbonne, Bothwell made the acquaintance of Dr Clem Finch, who would later become a collaborator in numerous research projects and publications, as well as a long-standing personal friend. The work on internal and external iron transport that Bothwell had been undertaking coincided with the research of Finch, who consequently invited him to join his laboratory in Seattle, at the University of Washington's Department of Haematology. The work undertaken in this laboratory at this time would lead to pioneering developments in haematology over the following decades. During this time, Bothwell's research focused on factors regulating the transport of iron in the system, including iron absorption and iron transport to the erythroid marrow and foetus.

Returning to South Africa in 1957 to continue his research at the University of the Witwatersrand, Bothwell was disappointed in the limited research facilities and funding at his disposal, placed as they were in the cardio-pulmonary unit rather than in other disciplines, including haematology. In order to establish a laboratory which would satisfy the immediate needs, a veranda needed to be enclosed and converted. While still comparatively modest, these facilities were adequate to fulfill the original intentions of this unit in studying autopsy subjects and documenting the prevalence and severity of iron overload in the black population in Johannesburg. Findings soon demonstrated the impact of iron overload on tissue, and within a short period, numerous spin-off studies were being undertaken with unanticipated results, including the highlighting of the relationship between high concentrations of iron and ascorbic acid deficiency extending to scurvy. The connection of these factors to osteoporosis was also under investigation.

Approximately 20 per cent of black adult males who came to necropsy showed levels of iron concentrated in the liver similar to those of patients with idiopathic haemochromatosis, as had been the case with the patient who had initially sparked Bothwell's interest in research as a young intern. However, findings in other subjects over the years suggested that iron overload was not due to an abnormality in absorption but was due to excess iron in the diet. Research by Dr ARP Walker was the first to find that the diets of many Africans at the time were exceptionally high in iron. This was due in part to the consumption of home-brewed beer routinely brewed in large iron drums – a result of legislation at the time curtailing the purchase of liquor by blacks. Not only was the level of consumption of iron in this beverage excessive; the iron also appeared to be particularly well-absorbed through this medium.

When the liquor laws were eventually altered in 1963, there was a corresponding decrease in prevalence of iron overload in this population. Eventually, this led to a subsequent shift in the direction of the laboratory's research; a shift with impetus added by the World Health Organisation's interest in analysing the prevalence and causes of nutritional anaemias, as well as developing strategies through which these deficiencies could


be counteracted. Studying numerous liver samples, Bothwell was struck by how disparate iron concentrations were found to be in populations of different countries, particularly the low levels of iron in subjects originating in India. In addition to this, Bothwell undertook research collaborating with researchers across three continents in order to delineate the limits of iron excretion in humans. The data gathered in this study underlined the limited capacity of the body to excrete iron through sweat, or other means.

RESEARCHER TO TEACHER

In 1967, Bothwell was appointed as Academic Head of the Department of Medicine at Wits and Chief Physician at the Johannesburg Hospital, a position he held until 1991 – an intense administrative load added to a flourishing research career. The Department of Medicine was the largest in the country and Bothwell developed a teaching ethos for generations of medical students that put him in the forefront of medical educators in South Africa. Parallel to his teaching and administration, Bothwell spearheaded the Iron and Red Cell Metabolism Unit. This was a research programme funded by the CSIR.

Taking on this role in 1963, Bothwell was able to conduct his research focusing on iron deficiency anaemia through this platform. This unit was taken over by the South African Medical Research Council upon its establishment in 1969. Continuation in this programme was ensured under the auspices of the International Atomic Energy Agency despite the withdrawal of South Africa from the World Health Organisation. The programme was later absorbed into the activities of the International Nutritional Anaemia Consultative Group, part of the US Agency for International Development. Through intensive research carried out over the span of over three decades, Bothwell was able to make numerous contributions to the field. In his own writings, Bothwell describes the two most noteworthy contributions as being the demonstration of the widespread pathologic sequelae of dietary iron overload as well as the delineation of the factors affecting the manner in which dietary iron is absorbed.

These latter findings represented a major shift in the understanding of nutritional iron intake – rather than focusing merely on the amount of iron



provided through diet, it was found that the exact composition of the diet plays an important role as well. Thus, meat and ascorbic acid were found to act as enhancers of iron absorption, stimulating the uptake of dietary iron into the bloodstream. On the other hand, largely cereal-based diets rich in phytates and polyphenols (such as the tannins found in tea) were found to suppress the absorption of iron. Utilising the findings which had been made, Bothwell was involved in numerous studies around the issue of iron fortification of foods. These iron-enriched foods could contribute to programmes aimed at preventing future cases of iron deficiency over the long term. Supplementary to these studies, the potential of organic acids, particularly ascorbic acid as well as the chelate NaFeEDTA, was explored as an enhancer of dietary iron absorption. The value of NaFeEDTA was confirmed in a large-scale pilot fortification trial carried out in Durban with curry powder being used as the vehicle and NaFeEDTA as a fortificant. Similar studies have been conducted subsequently, in Vietnam with fish sauce as the primary vehicle, and in China with soya sauce.

In 1992, Bothwell was appointed as Dean of the Faculty of Medicine at Wits. He held this position until his retirement, whereupon he was made an Honorary Research Fellow. As a specialist in his field, he has acted as an expert advisor to a number of ministerial task teams.

Over the course of a distinguished career spanning more than five decades, Bothwell has published over 300 full-length academic articles, served on numerous committees and panels, been a frequent presenter at conferences and has supervised eighteen doctoral students. He has also served as editor and reviewer on numerous renowned journals. He was a member of the Scientific Advisory Council of the Prime Minister from 1983 to 1986, and was President of the South African Society of Haematology.

Bothwell received abundant honours as a researcher, as well as in the role of a teacher. In 1973, he was made a Fellow of the Royal Society of South Africa, and in 1975 he was awarded the honorary position of Fellow of the American College of Physicians. He is also a Fellow of the Royal College of Physicians of Edinburgh and of London, and in 2001 was elected as a Member of the Academy of Science of South Africa. He has been awarded honorary doctorates from the universities of Cape Town and Natal as well as his *alma mater*, Wits.

His keen perception and sense of humour are evident in his written account of his career, *Iron in the Soul*. While some of the anecdotes are extremely comical, this portrait also highlights some of the nutritional challenges facing South Africa. Throughout these decades and those to come, Thomas Bothwell's groundbreaking contributions remain fundamental to efforts being made to reduce nutritional anaemia and inform future researchers in the field of iron balance.

Professor Thomas Bothwell passed away in 2016.

| SYDNEY BRENNER |

TOP THREE AWARDS

- Nobel Prize in Physiology, 2002
- Albert Lasker Special Achievement Award, 2000
- National Order of Mapungubwe (Gold), 2004

DEFINING MOMENT

To view the DNA model for the first time.



A LIFE DEDICATED TO SCIENCE

In the more than eight decades that Nobel Laureate, Prof Sydney Brenner, has all-consumingly devoted his life to science, he twice wrote powerful proposals of no longer than a page. Short but sweet, these kick-started the two projects that are part of his lasting legacy.

The first was to request funding to study a worm, because he saw in the nematode *Caenorhabditis elegans* the ideal genetic model organism. He was right, and received the Nobel Prize for his efforts. The other proposal, which set out how Singapore could become a hub for biomedical research, earned him the title of “mentor to a nation’s science ambitions”. Brenner’s way of approaching a task or a problem is often atypical, but it bears much fruit. Former colleague David Lane explains in *Sydney Brenner: a Biography* by Errol C Friedberg: “Those who want things to be very structured and stable don’t suit Sydney’s personality very well. He’s the sort of guy who enjoys tossing the hand grenade around. He asks the tough questions and if he sees things looking too settled and not moving forward in a new direction he stirs things up.”

At the age of 89, Brenner has no inclination to retire. As ever, it is genomics and especially genome evolution that captivates him. This Senior Fellow of Singapore’s Agency for Science, Technology, and Research (A*STAR) still leads a team of scientists building models to explain how induced pluripotent stem cells can be genetically developed into adult cell types. He also holds senior faculty positions at the Salk Institute and the Howard Hughes Medical Institute in the US.

“There is nothing more interesting and more exciting than being a working scientist,” he explains. “I am thankful that although I have several physical disabilities my brain seems to have retained most of its capacity, and of course I am very much indebted to my doctors for keeping me going.”

C. ELEGANS WORK

“To start with we propose to identify every cell in the worm and trace lineage. We shall also investigate the constancy of development and study its control by looking for mutants,” is how Brenner ended his proposal on *Caenorhabditis elegans* to the UK Medical Research Council in October 1963. He was looking for a new challenge after already having helped to show that genetic code is composed of non-overlapping triplets and that messenger ribonucleic acid (mRNA) exists.

His first paper on *C. elegans* appeared in *Genetics* in 1974, and in all, the work took about 20 years to reach its full potential. In 1998, thanks to a research consortium in the UK and US, this soil organism became the first multicellular organism to have its complete genome sequenced.

The 2002 Nobel Prize for Physiology was awarded to Brenner and colleagues Robert Horvitz and John Sulston for their combined body of work. Their discoveries concerning the genetic regulation of organ development and programmed cell death opened up new avenues for biological and medical research. It provided new insights into the development of organs and tissues and why specific cells are destined to die, for instance during heart attacks and strokes. It also helped the understanding of how certain viruses and bacteria attack cells.

During the award ceremony, Prof Urban Lendahl of the Nobel Committee explained how Brenner took up the challenge to find a species that is simpler than humans, but is still sufficiently complex to allow for general genetic principles to be deduced.

Lendahl explained: “His choice was the nematode *Caenorhabditis elegans*. This may at first seem odd, a spool-shaped, approximately 1 millimeter long worm with 959 cells that eats bacteria, but Brenner realised in the early 1960s that it was what we today would call ‘loaded with features’. It

was genetically amenable and it was transparent, so that even cell division and differentiation could be directly followed in the worm under the microscope. Brenner demonstrated in 1974 that mutations could be introduced into many genes and visualised as distinct changes in organ formation. Through his visionary work, Brenner created an important research tool. The nematode had made [it] into the inner circle of research."

SINGAPORE'S MENTOR

In Friedberg's biography, Brenner describes the succinct initial plan he drew up that would see Singapore's government finance cutting-edge research facilities in molecular and cellular biology from the early 1980s:

"Knowing that busy people don't like reading lengthy documents and mindful of Winston Churchill's famous admonition that he didn't like reading anything that was more than one side of a single sheet of paper, I wrote out a basic plan for the future on a half of one side of a single sheet of A4!"

This led to the opening of the Institute for Molecular and Cellular Biology (IMCB) at the National University of Singapore in 1987 to train Singaporeans and provide research infrastructure. A*STAR was established in 1991 to foster scientific research and talent in a knowledge-based economy. Since 2009, the Molecular Engineering Lab (MEL) at the Biopolis has provided space for recent PhD graduates to work without constraints within an interdisciplinary environment.

These endeavours have proven that Singapore, despite being a tiny population with little experience in basic research, can produce high-calibre scientific research. When Brenner accepted the Singapore National Science and Technology Medal in 2006, he said: "Here we now have hundreds, no thousands of young people devoted to science and to a career in biomedical research – and that's an opening to the new world."

Brenner enjoys iconic status in Singapore and is an honorary citizen of the country. There is even a hybrid named after him in the National Orchid

Garden. In October 2015, a two-day event celebrated his pioneering work, and included the opening of an exhibition about him.

Amongst the most notable work of his IMCB research team is that on the fugu puffer fish (*Takifugu rubripes*). The fugu and human genomes share similar blueprints, even though the former is about eight times smaller than the latter. Like *C. elegans*, the compact fugu genome is an ideal model for studying larger and more complex genomes.

FORMATIVE YEARS

In his autobiography *My Life in Science*, Brenner writes: "There has been only one quest, the quest to find out how organisms are encoded by their genes, to study that unique property of biological systems that distinguishes them from all other complex natural systems, of containing an internal description of themselves".

His part in this quest started at a very young age. As a three-year old he experienced one of the first turning points in his life. "I stopped being a baby and I gained a determination to do something in life," remembers Brenner, who was born on 13 January 1927 in Germiston and could read by the age of five.

After skipping a few grades, a 15-year old Brenner started medical training at the University of the Witwatersrand (Wits). It wasn't necessarily that he wanted to become a doctor. He saw it as a way to become a working scientist – an aspiration he had held ever since reading *The Young Chemist* by F Sherwood Taylor as a nine-year old.

He obtained his MBChB degree in 1951, after interrupting his medical studies for three years to do basic scientific studies and to obtain an MSc degree. As a somewhat reluctant medical student he lacked the same single-minded passion for his clinical studies as he had for his part-time research work. After failing his final clinical medicine exams, Brenner had to extend his training by six months to qualify as a doctor. He never practised.

His career as an independent researcher took off in 1945 during his Honours year, when he published his first scientific paper in the *South African Journal of Medical Science*. It was about the use of fluorescence microscopy to study the effects of Pellagra, a disease caused by chronic vitamin B deficiency. It was followed by a second in the science weekly *Nature*.

In between studies Brenner was also involved in student politics as Director of Research and Study of the National Union of South African Students (NUSAS) and as President of the Wits Student Representative Council.

His name lives on at his *alma mater* through the Sydney Brenner Institute for Molecular Bioscience. Sydney Brenner Institute for Molecular Bioscience was a virtual institute approved in 2009, but formally constituted in January 2014. In the late 2000s, he also enjoyed South African ties with the Stellenbosch Institute for Advanced Study (STIAS). Among the 26 honorary degrees bestowed on this recipient of the prominent Albert Lasker Award are four from South African institutions, and among the long list of accolades also the country's National Order of Mapungubwe in Gold.

It is at Wits where Brenner's wife, May Balkind, first noticed him while he gave one lecture on basic statistics to her psychology class. They married when both were studying in the UK. Brenner was working towards his DPhil at Oxford University, thanks to a coveted Overseas Scholarship of the Royal Commission for the Exhibition of 1850, while May studied at London University. The couple, who had four children, was married for nearly 58 years before May passed away in January 2010.

MOLECULAR WORK

Yet another important turning point occurred in April 1953 when the 26-year old Brenner was working on his doctorate. Along with fellow scientists from Oxford he drove to Cambridge to view James Watson and Francis Crick's newly unveiled DNA model. Brenner spent some six hours in deep

conversation with Watson about the possibilities it opened up for molecular biology, and the three subsequently struck up a lifelong working relationship.

Between 1954 and 1956, Brenner taught physiology at Wits – the only time he was employed in South Africa. For the next 35 years he worked at the Medical Research Council's Laboratory of Molecular Biology (LMB) in Cambridge, and became part of the 'renaissance of biological discovery'.

Most notably, together with Crick and others, Brenner showed that the genetic code is composed of non-overlapping triplets. Three bases, or a codon, encoded one amino acid, which is the basic building block of proteins. Together with Francois Jacob and Matthew Meselson he also proved the existence of messenger RNA (mRNA), which explains how information is transferred between DNA and proteins.

In a booklet published in Singapore in October 2015, James Watson wrote: "Genomics owes a great deal to him [Brenner] and his ideas; not just for the worm, which is what his Nobel Prize was for, but also technologies like massively parallel signature sequencing, which allowed gene expression to be analysed on a scale few could have imagined earlier".

SCIENCE COMMUNICATOR

A journalist once wrote about Brenner: "When he starts to talk you are swept along in the icy, buffeting current of ideas, shocked and exhilarated to the point of exhaustion – and still he goes on talking. Profundities, puns, anecdotes and opinions all rush and jumble together".

Brenner is indeed known for his wit, his all-consuming work ethic and his ability to keep a conversation going into the early hours of the morning. This seasoned traveller can also clearly and colourfully explain difficult scientific concepts. From 1994 to 2000, he for instance wrote monthly columns for *Current Biology*.



About the need to communicate science, he says: "I like to talk as I think we all need to keep the conversation going. And I think many things can be explained quite simply. The important point is that we are not machines performing tasks but human beings".

A decorative vertical element on the left side of the page, featuring a series of overlapping, wavy, golden-yellow lines that create a sense of depth and movement, resembling a close-up of a textured surface or a stylized flame.

A MENTOR TO OTHERS

Brenner served as LMB Director between 1979 and 1986, and then until 1991 as Director of the MRC's Molecular Genetics Unit. During his Cambridge years, he enjoyed various associations with other British and American institutes, including The Salk Institute, The Scripps Research Institute and the Neurosciences Research Programme. From 1996 to 2001, he was President and Director of Science of The Molecular Sciences Institute at Berkeley.

In his later life Brenner not only took on Singapore's development, but also two other major mentoring efforts: the Okinawa Institute of Science and Technology (OIST) in Japan and Janelia Farm at the Howard Hughes Medical Institute in the US.

In his biography, Friedman sums up the differences between Brenner's various "grand mentoring efforts". "The Singapore enterprise represents an excellent example of Brenner's skill in harnessing the energy, commitment, and financial resources of a young and prosperous country eager to join the front rank of international biomedical research."

"In contrast, OIST provides an educational example of how long-standing cultural influences that are per-

ceived to hinder cutting-edge research can be altered... The Janelia Farm experiment is designed to free outstanding young scientists from the onerous burden of writing grants in search of financial resources from funding entities not known for supporting high risk and innovative science. It is also a heroic attempt to bring scientists from multiple scientific disciplines together in the hope of achieving the sort of cross-fertilisation that is difficult, if not impossible, to achieve in more structural environments."

What has driven Brenner to take on challenge after challenge, even well after retirement age?

"I believe that we should not be judged by our prizes and medals but more by what we leave behind in the science that we have created and the people we have influenced and trained," says Brenner, who counts five Nobel Laureates among the postdoctoral students he has mentored.

"It is very difficult and often a waste of time to try to change the present as the forces of conservatism are very strong," notes Brenner. "But, as Max Planck observed, those in power are old and will retire and die. The young will inherit the future and that is why I work as much as possible with young people."

| JUSTICE ARTHUR CHASKALSON |

TOP THREE AWARDS

- Honorary Membership of the New York City Bar, 1985
- Order of the Baobab (Gold), 2002
- Human Rights Award (Foundation for Freedom – Switzerland), 1990

WHAT PEOPLE DO NOT KNOW

He was a first-rate football player and was selected for the combined South African Universities football team in 1952.



UNWAVERING TRANSPARENCY AT THE ESSENCE

South Africa is considered to have one of the best, if not the best, Constitutions in the world. And its custodian, the Constitutional Court, has as its justices some of the finest legal minds in the country. The Honourable Chief Justice Arthur Chaskalson played central roles in helping to draft and shape the Constitution and the establishment and promotion of the Constitutional Court – long before becoming the President and then the Chief Justice of this court.

Born in Johannesburg, Justice Chaskalson matriculated at Hilton College and went on to obtain BCom and LLB degrees from the University of the Witwatersrand (Wits). To capture the essence and significance of his life, following this seemingly straightforward beginning, is not an easy task – but two quotations help to create a foundation from which to start. The citation accompanying the Gruber Prize for Justice¹ that he received in 2004 included these words:

If a life could be mapped, that of the Honourable Arthur Chaskalson would surely appear as a straight line starting from a commitment to human rights and leading, without deviation, to the bench of the Constitutional Court of South Africa and the position of Chief Justice. It is a long line, but an unwavering one.

The citation might have added that the straight line was one that joined together a large number of dots along the route, each of them of considerable significance.

The second quotation comes from Senior Counsel Geoff Budlender's memorial tribute to Justice Chaskalson:

¹ The Gruber Prize for Justice is one of five international prizes awarded by the Peter and Patricia Gruber Foundation. Recipients are selected by a distinguished panel of international legal experts from nominations received from around the world. The prize is presented to individuals or organisations for contributions that have advanced the cause of justice and is intended to acknowledge individual efforts, as well as to encourage further advancements in the field and progress toward bringing about a fundamentally just world.

...there was transparency in everything he did. He was a person of rock-solid integrity and morality. ... His core belief was that it was human beings who were really important in life – and therefore also in the law. He put people at the centre of everything which he did.

Chaskalson grew up in the 1930s and early 1940s “as a little white boy in a middle-class home in an area where I met other little white boys and girls”. Discrimination against and segregation and marginalisation of black South Africans were realities long before the formalisations of apartheid, and it is likely that these circumstances influenced his decision to become a lawyer while he was still at school.

At Wits he studied for a BCom degree, not because he wanted to do so, but because an undergraduate degree was a requirement for entering the LLB programme. At the time, Chaskalson felt that the BCom was a waste of his time – although later in his career it stood him in good stead – the basis for his work in Commercial Law.

His time at Wits introduced him, though, to a world that his childhood had placed beyond his experience. Not just the reality of apartheid (his first year at Wits was in 1949 when the National Party came into power) but the extent and horror of both pre-apartheid discrimination, and the extent and enormity of the unfolding legalised inequity, confirmed his decision that his future lay in the law.

In fact, his unexpected introduction to the importance of clear thinking and the value of precision came, at Wits, when he spoke up for George Bizos, a fellow student. Bizos was facing a vote of no-confidence from his fellow members of the Wits Student Representative Council (SRC) due to his ‘radical’ views, and the debate raged on endlessly until Chaskalson (a first-year student) stood up and pointed out the wrong questions were being asked and debated: what is the University's policy?; what has it been?; what should be? These were irrelevant, he said, because there was only one important question: “what is right and what is wrong?”

After graduating and, subsequently, becoming an advocate and being admitted to the Johannesburg Bar, Chaskalson worked in a highly successful commercial practice, primarily as a civil lawyer. He engaged in very few criminal matters – and those that he did take on were *pro deo* cases that he undertook for the organisations Defence and Aid and the Legal Aid Bureau. He initially found the *pro deo* work distressing, since Criminal Law was not his area of speciality and many of his cases carried the possibility of a death sentence, which he abhorred. But his work for Defence Aid and The Bureau resulted in his beginning to build a practice in rights work during the early 1960s.

ONWARD TO POLITICAL TRIALS

He very soon built up a practice in Public Interest Law and took on several political trials in which the accused were charged with sabotage related to the Suppression of Communism Act (*Act 44 of 1950*).

In 1963, Chaskalson was asked to join the defence team as a junior member in what became known as the Rivonia Trial, in which Nelson Mandela and nine others were to face unclear charges (under *Act 44 of 1950*). The lead-up to the case was a shambles – dates weren't set, the exact charges weren't specified and the members of the defence team were given very little time to prepare their case. It was Chaskalson who finally managed to get the organisational situation resolved and, by the end of the trial in 1964, he had eroded a substantial portion of the State's case and so played an important part in having the anticipated death sentence reduced to life imprisonment.

Similar cases revolving around apartheid laws followed, each eroding elements of apartheid. In 1975, he so confused the judge in a case that forbade a Mr and Mrs Komani to live together that, despite claiming to having been led down a garden path, the judge could find no flaw in Chaskalson's argument and the couple were finally allowed to live together. In 1977–1978 he defended the so-called Pretoria 12 – one of whom was Tokyo Sexwale.

In 1983, in the so-called 'Rikhotso' case, Chaskalson's victory changed the lives of more than 150 000 black men who, following the judgement, were allowed to bring their families to live with them in the residentially segregated areas in which they worked.

Chaskalson was also extensively involved in the professional structures of his profession. He was a member of the Council of the Johannesburg Bar Council for a total of 15 years (over two periods), and Chairman of the Council in 1976 and 1982. For 12 years, he served on the National Bar Examination Board (as Convenor for part of his time) and, for five years, as the Vice-Chairman of the General Council of the Bar of South Africa.

While fighting for human rights in the South African courts, Chaskalson helped establish the Legal Resources Centre (LRC) in 1979 along with Geoff Budlender and Felicia Kentridge. Specialising in defending human rights, the LRC was one of the first public interest law centres to be established in South Africa. Not only was this a major development for the practice of law and legal training – it also reflected Chaskalson's commitment to the profession's work: he had to convince the Council of the Johannesburg Bar that the LRC could function with both attorneys and advocates working collectively, at a time when this was considered by the Council to be unprofessional.

He agreed to serve as the National Director of the LRC for two years although he gave up his other work and lead the LRC for 14 years as his primary job. Two years later (in 1980), he created a fellowship programme within the LRC to support (primarily) young black women candidate attorneys. In 1993, he stepped down as the National Director of the LRC, then, and now, known as one of best public law 'firms' in the world.

By this time, Arthur Chaskalson was an internationally recognised and respected human rights lawyer and jurist, and the nature and scope of his work began to expand both within and beyond South Africa's borders.

In late 1989 and early 1990, he played an important role as an advisor to the Namibian Constitution Assembly – with the then Prime Minister of Na-

mibia, Hage Geingob, suggesting that he had played more of a role in the creation of that country's constitution than he ever spoke about.

FROM APARTHEID TO A CONSTITUTIONAL DEMOCRACY

In 1991, negotiations around the transition from apartheid to a constitutional democracy in South Africa began and, after faltering, started again in 1993, focusing on the development of an interim and then final Constitution. His influence is clearly visible in the text which was finally approved. Geoff Budlender states that Chaskalson “fingerprints are all over the document. You see them in the care, precision, and attention to detail; and you see them in the Constitution’s recognition that we need to go beyond a typical liberal constitution, which aims to limit the power of the state”.

In 1994, President Nelson Mandela appointed Chaskalson as President and later (after a title change) as the Chief Justice and Head of the Constitutional Court. In the lead-up to the formal opening of the Court in 1995, he had worked consistently to ensure that the Court would have the means to allow it to function effectively. He was able to oversee the new (present) Court Buildings when they were opened on Constitution Hill in Johannesburg – in 2004. He used the opportunity to make it clear that the Constitution (and so, then, the Court) did not simply dismantle the old apartheid laws but had to do much more than that. “It demands that our society be transformed from the closed, repressive, racial oligarchy of the past, to an open society based on the founding values of democracy, human dignity, equality and freedom – values which must now inform all aspects of our legal order.”

In 1995, he became a Commissioner of the International Commission of Jurists and served as its President from 2002 until 2008 – and also served as a member of the United Nations Permanent Court of Arbitration.

In 1999, he was appointed to the United Nations Permanent Court of Arbitration – all this while continuing his responsibilities as Chief Justice. He retired from the Court in 2005 and was succeeded, most appropriately, by his Deputy, Justice Pius Langa.

In his years of retirement, Chaskalson was acutely aware of new legislation being proposed and, when he believed that a proposed act was in contravention of the Constitution, he didn't hesitate to comment on it.

For all his local and international achievements and honours, and the positive impact his work has had on many facets of South African life, friends and colleagues report that Chaskalson was consistently modest and meticulously polite and courteous – even when dealing with his ‘opponents’. These same sources describe him as a shy man whose shyness was sometimes interpreted as his being distant whereas, in fact, they attest that he was as warm and approachable as he was modest.

Apart from his being shy, something that not many people realise is that, in his young days, Chaskalson was a first-rate football player and was selected for the combined South African Universities football team in 1952.

For most people, however, Arthur Chaskalson became the personification of the values of the Constitution and their implementation. What greater contribution to society might a scholar/jurist and humane judge make?

Margaret Marshall, Chief Justice of Massachusetts in the United States, put it this way:

What a voice his has been. Precise, learned, thoughtful, compassionate and highly persuasive.

Just as well, for society and for each of us individually, since one of the Honourable Judge's sharpest lines was that “Governments are not the natural protectors of rights”.

The writer wishes to acknowledge the considerable help of Justice Richard Goldstone and Ms Alice Brown in providing information about, and insights into, the life of Justice Arthur Chaskalson who passed away in 2012.

| ANUSUYA CHINSAMY-TURAN |

TOP THREE AWARDS

- SA Woman of the Year, 2005
- The World Academy of Sciences Award, 2013
- ASSAf Science-for-Society Gold Medal, 2015

DEFINING MOMENT

The decision to pursue postgraduate studies in palaeontology rather than becoming a teacher.

WHAT PEOPLE DO NOT KNOW

She loves baking, and has a very creative alter ego, with handicraft abilities, and can do anything from knitting, pottery, photography and mosaic work to jewellery-making.



BREATHING LIFE INTO THE BONES OF EXTINCT ANIMALS

Anusuya Chinsamy-Turan was born in Pretoria, The youngest of three daughters, her sights were firmly set on becoming a science teacher. Education was, after all, part of her DNA. It is the profession followed by her eldest sister and her father, a headmaster, and several others in her extended family.

In the 1980s apartheid years, tertiary study options for Indian South Africans were generally limited to the University of Durban-Westville. Motivated by her father, Krishna Chinsamy, she applied to study at the University of the Witwatersrand (Wits), which was one of the more liberal white universities at the time.

A little white lie on her admission papers later, almost seems prophetic. When applying for special ministerial consents, black students had to provide a reason for wanting to attend a so-called white university. Chinsamy-Turan wrote that she wanted to study palaeoanthropology, for which Wits has always been renowned.

Back then, she had no inkling that one day she would become a palaeontologist. With her heart set on becoming a high-school science teacher, she just wanted access to a good degree in the sciences at Wits.

She took palaeontology options in her third and Honours years. This changed her career trajectory and shaped her into a Fellow of the University of Cape Town (UCT), the Academy of Science of South Africa (ASSAf), the Royal Society of South Africa and The World Academy of Sciences (TWAS).

For her Honours in Zoology, Chinsamy-Turan had chosen a project that involved a study of the development of the trachea or windpipe in mice. The project involved the sacrifice of pregnant female mice and a dissection of the embryos. "I absolutely hated it with such a passion that it made me decide that I did not want to ever do any experimentation on living animals," she says with emphasis.

Luckily she found solace in palaeobiology. "Instead of killing something, here I would be able to reconstruct something long-dead as a once-living animal," she remembers.

The supervisor of her MSc, Prof Mike Raath, introduced her to the emerging field of fossil bone histology, which is preserved even after millions of years of fossilisation. It has allowed Chinsamy-Turan to combine her background and interest in zoology, biology and histology to study extinct animals. Her MSc was upgraded to a PhD, which she obtained in 1991.

BONE PI

Chinsamy-Turan has since spent much time peering down a petrographic microscope looking at ultrathin slices of fossilised bone. It is all about comparing them with those of living animals to work out how particular dinosaurs grew and lived. "Like a detective, we use every single clue that is preserved in the fossil record to try and reconstruct extinct animals, such as dinosaurs."

"Bone preserves the texture and the signals that tell us how these animals actually grew," explains this board member of the Jurassic Foundation, an American-based grant programme for young palaeontologists and especially postgraduate students that was set up as a spin-off from the original very successful Jurassic Park movie.

It is about much more than just putting an age to specimens. The actual growth dynamics of the fossilised animal is recorded within the microscopic structure of fossilised bone – similar but not exactly like those of tree rings. "The microscopic nature and texture of the bones tell us how fast the animals were growing, if they were affected by disease, or what the influence of seasonality might have been on their growth," Chinsamy-Turan explains the basics behind the particular field of palaeoscience detective work in which she is involved.

She believes it is relatively easy to spot disease or pathologies in fossil bones. "If you know what is normal, then you can easily recognise abnormalities when you see them."

In 2014, for instance, she co-authored two papers showing that dinosaurs suffered from diseases that had manifested in their bones, such as infections. In the same year, she was also part of an international team that described *Changyuraptor yangi*, a 125-million year old dinosaur fossil with long tail feathers found in China. It is one of the several discoveries of new species that she has been involved in.

Chinsamy-Turan still remembers the moment she peered through the microscope at a thin slice of a fossilised bone of a Mesozoic bird one late morning in 1993. It was towards the end of her first postdoctoral year at the University of Pennsylvania in the USA, and at the time she was already one of the few people with expertise in fossil bone microstructure. She started collaborating with Luis Chiappe, then of the American Museum of Natural History, to examine three specimens of early birds from Argentina.

"Immediately, when I looked at the sections of bone under the microscope, I knew that our findings were significant – a breakthrough, a *Nature* paper," she recalls the impression that the specific organisational structure of the bone had made. These early Mesozoic birds were growing more like their dinosaurian relatives, rather than modern birds.

These findings were introduced to scientific literature in *Nature* in 1994. Since then Chinsamy-Turan counts a total of seven papers in *Nature/Nature Communications/Scientific Reports* among her more than 85 peer-reviewed publications.

Chinsamy-Turan has worked on dinosaurs and other fossils from various localities in South Africa, Africa and other parts of the world. For example, she and her students and postdoctoral researchers have contributed much to understanding the biology of South Africa's famous mammalian reptiles that eventually evolved into mammals.

She also has a particularly soft spot for the derived meat-eating dinosaurs that are close to the origin of birds. Because these dinosaurs, and early (Mesozoic) birds are not found in South Africa, she often collaborates with colleagues from China, Argentina and the USA.

Chinsamy-Turan is fascinated by these 'transitional' groups. She is engaged with questions about how the long-necked dinosaurs evolved from their basal ancestors, how birds evolved from non-avian dinosaurs and how mammals evolved from mammal-like reptiles.

She is currently collaborating on efforts to work out how early sauropodomorph dinosaurs gained their massive size and gave rise to the gigantic and iconic long-neck dinosaurs that so often hoard the limelight. The early radiation of these dinosaurs is particularly well known in South Africa and Argentina.

TELLING SCIENCE AS IT IS

Her life in academia started in 1988 at the Bernard Price Institute for Palaeontological Research at Wits when she was appointed as a part-time junior lecturer. She completed her PhD during this time.

After finishing her postdoctoral fellowship in the USA, Chinsamy-Turan and her husband moved to Cape Town in 1994 where she took up a position as specialist scientist at the South African Museum. A secondment to UCT for 50% of her time followed in 1997, during which time she also served as Associate Professor in the Department of Zoology. Because of her commitment to science communication/promotion, she took two years leave of absence from UCT to serve as Director of the Natural History Collections at Iziko Museums in Cape Town. In 2002, she returned to UCT in a full-time capacity and was promoted to full Professor in 2003.

To her, life is however more than just about climbing the ranks. She regularly instigates and leads science-related awareness campaigns, and has over the years been involved with numerous outreach projects, lecture series or poster campaigns. She has served on the editorial board of the popular science magazine *Quest* from 2004 to 2015. She has chaired the Advisory Board of Scifest Africa, South Africa's annual science festival in Grahamstown, and helped to develop dinosaur exhibitions in Cape Town and Tokyo. Interesting content and titles of workshops or lecture series such

as *Sitting Ducks* or *Charging Bulls* and *Conquerors of the Air* has made her a popular speaker worldwide.

The example of her charismatic postdoctoral advisor, Peter Dodson, influenced the way in which she tackles the business of telling others about her research and science in general. Chinsamy-Turan, the successful science communicator, also has much to do with her said educator DNA.

Her first book contract – for *The Microstructure of Dinosaur Bones: Deciphering Biology through Fine-scale Techniques* published in 2005 – came about thanks to her ability to talk about her work in a clear, yet insightful way. These are skills she believes she acquired because of her Higher Diploma in Education which she obtained in 1985 from the University of Durban-Westville.

After giving a talk at the annual conference of the Society of Vertebrate Palaeontology in New York, an editor from Johns Hopkins University Press complimented her on her excellent oral presentation. “Wouldn’t you like to write a book for us about it?” came the request.

This dedicated mother took up the challenge, and wrote her first book in the evenings once her two sons were in bed.

In this, as in most other things she takes on, her ability to plan and execute stood her in good stead. That, and of course the support of her husband, an engineer and Managing Director, Yunus Turan, which she describes as “essential”.

She has so far penned four books – two academic books and two popular books – contributed many a chapter of various scientific and popular texts and has written many popular articles too.

Her second academic book, *The Forerunners of Mammals: Radiation, History, Biology* followed in 2012.

Good-humouredly Chinsamy-Turan remembers how excited her sons’ young friends would be to meet their “dino expert mother”. With the publishing of her two books aimed at younger readers, her fan club has grown beyond the borders of Rondebosch and the UCT campus.

First came *Famous Dinosaurs of Africa* in 2008 (now in its second run), and then *Fossils in Africa* in 2015. The first has its roots in the two-year leave of absence she took in 2001 and 2002 to work as Director of the natural history collection division at Iziko Museums in Cape Town. During this time, she was instrumental in developing several new exhibitions, and she did the background research and application for the National Lottery funding for the African Dinosaurs Exhibition that opened a few years later.

She’s known as a good planner, a motivator and someone to whom especially other women scientists turn for advice. This former Vice-President of ASSAf and President of the South African Women in Science and Engineering (SAWISE) was also at the helm when the Department of Biological Sciences at UCT was formed through a merger of two departments.

Being a board member of the Jurassic Foundation and Chair of the US-based Society of Vertebrate Palaeontology’s prestigious Romer-Simpson Prize are among her current commitments.

She is after all a person who delivers on what she promises. “When I start something, I must finish it.”

Ultimately it’s her job and the various aspects thereof that keep her going: to breathe life into an extinct animal and to find enough detail so that its life’s story can become as real as possible.

“Each fossil has a unique story that needs to be told,” she says.

| PAUL CILLIERS |

TOP THREE AWARDS

- Harry Oppenheimer Fellowship Award, 2006
- Rector's Award for Excellence in Research, Stellenbosch University, 1989
- National Research Foundation, A-rating, 2008

DEFINING MOMENT

Cilliers discovered complexity theory while working as a senior researcher at the Institute for Maritime Technology in Simon's Town. His decision to move away from engineering and into philosophy was a defining moment in his career.

WHAT PEOPLE DO NOT KNOW

Besides being a great cook, wine enthusiast, musician, and insatiable reader, he also had a Class V Scientific Diver licence to conduct scientific work as a SCUBA diver.



UNDERSTANDING THE NATURE OF COMPLEXITY

Paul Cilliers passed away in 2011 leaving behind his family, friends and colleagues, and an impressive body of work on the topic of complexity.

It is hard to grasp his essence without the help of an interview, but the assistance of documents authored by Cilliers (and authored by others about Cilliers) allowed for a picture of him to emerge. His friend and colleague Jan-Hendrik Hofmeyr, also featured in this publication, provided insight for this profile, though Cilliers surely would have scoffed at any effort to reduce his life to a 2 000-word blurb as it goes against the fundamental principles of complexity.

Cilliers was born in Vereeniging in 1956. He was brought up in a household that encouraged critical thinking and social awareness. When he had completed his schooling at the Hoërskool Vryburger in Germiston, Cilliers moved to Stellenbosch to complete a Bachelor's degree in electrical engineering which he obtained in 1980. After two years of compulsory national service in the South African Navy as a senior researcher, he worked at the Institute for Maritime Technology in Simon's Town.

His primary role at the institute was to conduct research on pattern recognition, neural networks and artificial intelligence. He realised that his research involved complex systems and he began thinking about these systems in a philosophical way rather than a technical way.

As Hofmeyr puts it, "he wanted to explore the implications of acknowledging the complexity of the world in which we live". In order to pursue his interest in complexity, Cilliers started studying through the University of South Africa (Unisa) to complete his BA. He then did his Honours in political philosophy (*cum laude*, Stellenbosch University (SU), 1987). This was followed by his MA in philosophy in 1989 and his D Phil in 1994, all from SU. He was strongly influenced by his supervisor Johan Degenaar, the renowned Stellenbosch philosopher, and Mary Hesse, who is now an Emeritus Professor in philosophy of science at Cambridge University. All the while, he

continued working as a research engineer in Simon's Town, travelling the long distance to Stellenbosch for coursework, meetings and research. He was appointed as a lecturer in philosophy at SU in 1994 and became a full Professor within nine years.

Cilliers' dissertation, which became the book *Complexity and Postmodernism: Understanding Complex Systems* (1998), outlined complexity as Cilliers saw it. Hofmeyr was there to see him being "catapulted into the semi-stardom of complexity by his book". Cilliers' contribution towards thought, and especially scientific thought, was recognised with an A-rating the first time he applied to the NRF. "Unlike others who work up from a junior position," Hofmeyr explained, "Cilliers already had an excellent international reputation by the time he went in for his first rating". This recognition highlights Cilliers' significance as a researcher and also the importance of his subject material.

Science often studies systems in a reductionist way. Hofmeyr, who was intimately familiar with Cilliers' philosophy, described this as an isolation of parts. "The first thing you do with a living system is you kill it. You chop it up into bits and you study the bits, which is very important because otherwise you wouldn't know what's inside." However, studying the components of a system often ignores the interaction and relationships between those components. For example, if a disassembled machine is studied in terms of its parts alone, the function and purpose of the machine may be overlooked. In this way, complexity can be thought of in the Aristotelian sense of the whole being greater than the sum of its parts.

However, Hofmeyr was quick to point out that if this is the only way we think of a system, it is a gross simplification. He explained that, in a material sense, every system is the sum of its parts. Also in some sense, the system is larger than the sum of its parts, because once you put something together, the system has 'emergent properties' that you can't explain in terms of the properties of the parts. But the system can also be less than the sum of its parts. "What the system does is it constrains the behaviour of the parts. Your place in a society constrains your behaviour. You don't do all the things you could possibly do because of this constraint."

THE IMPORTANCE OF COMPLEXITY THINKING

In many ways, complexity avoids description. Cilliers disliked describing his work in a simplified way, because he understood that reducing the notion of complexity to a simplified definition went against the very nature of complexity itself. Instead his reluctant attempts at defining it rather focused on what complexity is not; complex systems do not have linear interactions between components within the system and with other systems. Nonlinear interactions produce emergent properties which cannot be predicted from the properties of the individual components. Emergent properties will also be present in any general attempt to model complex systems, making it difficult to match the properties of the model to the properties of the system. Cilliers' most cited, and in some ways most profound, statement regarding complex systems is this: "A Boeing engine is complicated, but a good mayonnaise is complex".

In many ways, complexity goes against the current scientific paradigm of linear cause and effect. However, Cilliers argued that to acknowledge complexity is not to be anti-scientific. He stated in his book that complexity in systems is rather an "argument against a particular scientific strategy that assumes complexity can be reduced to specific features and then represented in a machine... it is an argument for the appreciation of the nature of complexity, something that can perhaps be 'repeated' in a ma-

chine, should the machine itself be complex enough to cope with the distributed character of complexity".

Cilliers found that being a philosopher was a far more practical contribution to society than being an engineer. He was an excellent lecturer and introduced his students to a wide range of topics ranging from complexity theory to ethics, deconstruction to cultural philosophy. He built the Centre for Studies in Complexity with Hofmeyr, which allowed them to bring together their disparate fields, humanities and science, to create courses that bridged the gap between the fields and introduced complexity to a multitude of disciplines. Cilliers was also part of the Fellowship and Programme Committee of the Stellenbosch Institute for Advanced Study (STIAS) and is remembered for his immense contribution to the development of the Fellows programme.

The contributions by Cilliers and others in his field have allowed for researchers to apply complexity theory in ways that directly help society. For example, Dave Snowden (a Welsh researcher, academic, and consultant) developed a framework that allows those in a leadership or management position to understand complex situations and make decisions that acknowledge the complexity of the organisation or situation that they manage. This framework has been used by companies and governments alike to manage tough situations, engage with the public, and ultimately under-



stand how their decisions may lead to unexpected outcomes. Snowden's acknowledgement of Cilliers' influence on the design of his framework reinforces Cilliers' valuable contribution in philosophy.

It may be hard for scientists to see how philosophy could have a direct benefit to society. However, Hofmeyr is very convincing of its merit. "As I see things now, the greatest contribution from complexity lies not in its technological promise, but in the way in which it is influencing our understanding of the world. We should promote what can be called 'complexity thinking', a style of thinking which is critical of claims based on reductionist thinking, yet at the same time be mindful of its limits." In this way, any attempt that gets us to think harder and reflect on our practices will benefit society, as we, researchers and individuals, will be able to build better selves and better research by being more mindful and more critical thinkers.

Cilliers built his philosophy and arguments with a broad base of evidence in a way that allows his audience to come to conclusions on their own. In an essay he wrote called *On the Importance of a Certain Slowness*, he advocated for change at a speed that allows for reflection. He drew examples from history, technology, literature and philosophy and tied these examples carefully together with threads of inescapable persuasion. His language is direct and his arguments are so well-constructed that they are hard to refute. Not that his 'arguments' are about refuting. He makes no demands. He insists on nothing other than our acknowledgement that slowness has value. He reminds us of how work time and leisure time have been collapsed and how technology has assisted with the collapse. "Reflection involves delay," he wrote, "and in a cult of speed, delay is unacceptable." By giving us a space to reflect on time and slowness, he liberates a part of our perception and enables us to consider an alternative that we did not know was there before.

DECISIONS SHOULD NOT TRAP

Hofmeyr believes that the most important contribution Cilliers made was unfortunately towards the end of his career and was never fully realised.

Cilliers was influenced by Edgar Morin and used Morin's ideas as the foundation for developing his thoughts around the complexity of ethics, which was taken further by Rika Preiser, Cilliers' PhD student. Hofmeyr described Cilliers' approach to ethics as follows. "Never make a decision in such a way that you can never reverse it. You must always be flexible, and you must never paint yourself into a corner in a way that you can never escape from it again." This is incredibly important to remember in the current turbulent political climate in South Africa. The South African government, and also institutions of higher education, have big decisions to make. Cilliers' would have advised that changes be made in a way that doesn't trap us or bind us to those decisions. Because all systems have emergent properties, changes to a system will always have unintended consequences, outcomes that may not be predicted simply by examining the system in terms of a linear equation. Hofmeyr suspects that Cilliers would have advised us to try to understand the system and make small nudges of change. "See what the effect is. Do experiments that are safe to fail." Hofmeyr laughed and added, "Of course one seldom does that".

Cilliers' interests extended well beyond philosophy and complexity. In reading about him, it became clear that he was a well-rounded person who enjoyed many aspects of life. Cilliers loved his wife, Sandra, and his children, Ilana and Cornel. He also loved music and played the French horn in symphonic and chamber ensembles. He read as much literature as he could and regularly reviewed new novels. He was also an enthusiastic cook and very knowledgeable about wine, which could in part be attributed to his two-year Diploma from the Cape Wine Academy.

Cilliers is still very much alive in the minds and hearts of his colleagues, friends and family. "Once you've gone through Paul Cilliers," said Hofmeyr, "he's there for life. He makes you think differently about things." Hofmeyr still teaches about complexity, and Cilliers' examples and the way he described things are very much a part of the lectures. "He made a big difference in many people's lives. He was a very caring person and a wonderful friend to many." Although Cilliers is no longer with us, there is still the opportunity to meet him on paper and see how he brought complexity to life. Paul Cilliers, your community thanks you.

| EUGENE CLOETE |

TOP THREE AWARDS

- Academy of Science of South Africa's Science-for-Society Gold Medal, 2010
- Fellow of the International Water Association, 2010
- Havenga Prize of the *Suid-Afrikaanse Akademie vir Wetenskap en Kuns* (Biology), 2005

DEFINING MOMENT

Reading a book by Edward de Bono as an undergraduate student at the University of the Free State, and feeling a kinship with his ideas about lateral thinking and creativity.

WHAT PEOPLE DO NOT KNOW

I grew up on a farm in the Eastern Cape without mains water or electricity. We had a rainwater tank and I studied by candlelight.



THE SOLUTION SEEKER

Few academics can claim being natural entrepreneurs, but Professor Eugene Cloete is one of them. His curriculum vitae features not just his publications in academic journals, but also almost a dozen patents. He considers his “best idea ever” was using an empty teabag, replacing the tea with activated carbon and using antimicrobial nanofibres for microfiltration to make a filter that cleans water. *Voila* – an innovation that can save lives by making water safe to drink in poor, rural areas.

“I just love ideas,” says Cloete, who since 2012 has served as the Vice-Rector for Research, Innovation and Postgraduate Studies at Stellenbosch University (SU). Whether killing sludge-producing bacteria in cooling towers or cleaning water runoff from cattle feedlots, his talent lies in taking ideas from one field and using them to solve problems in another. In addition to being a Professor and university administrator, he has been and still is involved in science strategy. He has served on a multitude of boards across several disciplines, including the Council for Scientific and Industrial Research (CSIR) and the Water Research Commission (WRC). He has also served on the scientific committee of the Cancer Association of South Africa (CANSA).

His driving force is the desire to make a difference, especially in his own country. He regularly receives excellent job offers from abroad but has decided not to consider these. “The country where I can make the biggest difference with the qualifications and experience that I have, is South Africa,” he says.

EARLY LIFE AND EDUCATION

Cloete’s resourcefulness can be traced back to his childhood. Born in the Eastern Cape he grew up on a dairy farm near Lady Grey, just south of the Lesotho border. He comes from a long line of farmers. Cloete’s father was a very wise man. “He told me to specialise either in food or water, because it is what people will always need,” Cloete recalls.

As a young child on the farm, Cloete’s best friends were the children of the black farm workers. When time came for him to go to the local school, he

was upset because his friends could stay on the farm and play. Only later did he realise that he was the privileged one, who could go to school.

When not at school he would play with his friends on the farm. Once, they built a go-cart using an old ten-horsepower engine mounted on a crate frame with motorcycle wheels. They crashed it a lot. “What impressed me about my black mates was how creative they were, in terms of solving all sorts of practical problems on the farm,” he says.

At school, Cloete discovered an aptitude and fondness for science. He had a keen interest to study biology, but the school did not provide the option to do biology and science, forcing learners to choose between the two subjects. He chose science, because that would get him into a BSc programme. When Cloete went to university, he decided to pick up the biology he hadn’t learned. He enrolled to study microbiology at the University of the Free State, followed by an Honours and Masters degree in botany at the same institution and a DSc degree in microbiology at the University of Pretoria (UP).

During these years he started to see the challenges facing the country, and indeed the world, with regards to water. His father had been right – there were myriad problems to solve in the management and treatment of water. For his Masters thesis, he studied an aquaculture process for treating water run-off from a cattle feedlot housing a thousand cattle. Cloete devised a method to clean the highly contaminated effluent using bacteria-producing carbon dioxide, which in turn spurred the growth of algae that were used to feed fish. The water could then be recycled and the fish harvested as a cheap source of protein.

Cloete started working on his PhD at UP while doing compulsory military service. Thereafter he went to work for AECL, a chemicals company based in Johannesburg, where he completed his DSc in wastewater treatment in 1984.

At AECL, one of the projects he worked on involved controlling bacteria that cause corrosion in industrial cooling towers. The bacteria were nor-

mally controlled with chemicals, but soon the bacteria were developing resistance to these chemicals. He studied and elucidated the mechanisms by which the bacteria acquired resistance. This inspired him to develop a technique that killed the bacteria by 'exciting' the water with an electrical current, increasing the oxidation potential in the water. Due to high oxidative power in the water literally 'incinerating' the bacteria, the bacteria could not build up a resistance. The method was eco-friendly as it didn't use chemicals. The method is now used worldwide, including by companies like Coca-Cola.

ACADEMIC LIFE

Cloete took up a lecturing position at UP in 1986. In 1994, he was appointed as the Head of the Department of Microbiology and Plant Pathology. He stayed at the university until 2008. During this time he served as Chairman of the university's School for Biological Sciences and as Director of its Water Institute.

He also created a 'creativity' institute at the university, named after his colleague and mentor, the British physician, psychologist and inventor Edward de Bono. As an undergraduate, Cloete's worldview had been turned upside down when he'd read De Bono's book introducing the notion of 'lateral thinking'. That is, the practice of taking insights from one field into another to solve problems in innovative ways. "It was quite weird since it was as if he was describing me in that book," Cloete recalls.

A few years later Cloete got to meet De Bono in real life when the author was in South Africa for a visit. The author was interviewed on *Good Morning South Africa*, a TV talk show of which Cloete's brother-in-law was Director. Cloete's brother-in-law arranged a breakfast meeting with De Bono and the two connected instantly. The relationship led to Cloete launching the Edward de Bono Institute for Creativity at UP in 2005.

THE TEABAG FILTER

In 2009, Cloete moved to SU to take up the position of Dean of the Faculty of Science. This is where he had his idea for the water filter – a perfect example of lateral thinking.

Shortly after arriving at Stellenbosch, Cloete learnt about a recent PhD graduate who had developed a method for turning a polymer gel into silk-like fibres using a technique known as electro-spinning. Cloete and two of his postdoctoral fellows used this concept to develop an antibacterial gel that they could spin into nanofibres.

Using emptied teabags as the structure onto which to spin the antimicrobial nanofibres, Cloete and his students then filled the teabag with activated carbon – the cleaning agent in normal Brita filters – and sealed the teabag up again using a student's hair straightener. The filters worked perfectly in the lab.

That was the origin of Cloete's teabag water filter, an idea for which he was nominated for the 2013 Innovation Prize for Africa and featured in the 2010 December edition of *Scientific American* as one of ten world-changing ideas. Since then, the concept has led to the functionalising of nanofibres for numerous applications.

He is passionate about developing people and transforming the racial and gender profile of South Africa's universities. Of the 110 Masters and PhD students he has supervised, over half were women, and 68 were black. "When I look back at my career and I ask myself, what made my career worth something, the one thing that stands out is the students that I've supervised," he says.

Many of his students came from poor backgrounds, and often required some form of personal assistance to get going. "I have taken a lot of chances with a lot of students, and not one has disappointed me," he says. For instance, one of his students, a young woman from the Democratic Republic of Congo, pitched up at his office at UP on a Friday afternoon with her three-year-old son in tow. Cloete put her up in a hotel over the weekend, and the following Monday she became his student. She did a Masters and a PhD with him as her supervisor, and now she works as a Professor at Tshwane University of Technology, and the son has graduated with a degree in electronic engineering from the University of Cape Town.

FIXING THE FUTURE

Work as a Vice-Rector (where he sees his primary role as helping staff and students to become more successful) keeps him busy, but he still manages to squeeze in some innovative work. He currently uses his experience to solve problems in the field of water supply and sanitation. He believes that wastewater is a resource out of place. Dealing with sewage is a grudge activity for municipalities, and requires trained operators that we don't have and hence more than 50% of wastewater treatment plants in South Africa are dysfunctional. However, the main components of sewage – phosphates, nitrates, some minerals and organic matter – are useful resources used in biotechnological processes.

"Current sewage systems turn these resources into mountains of sludge that nobody knows what to do with," he says. His idea is to change the paradigm surrounding sewage treatment, using the resources to produce fine chemicals and other valuable products. This would monetise the activity, creating better sewage treatment solutions and jobs.

He also believes that households need to harvest rainwater, and he is involved in a project testing a rainwater harvesting-and-purifier system based on solar pasteurisation (another good example of conceptual and lateral thinking – based on the age-old process of pasteurising milk), in the Kayamandi informal settlement near Stellenbosch.

He believes that in the future, electricity generation and water provision will be decentralised to the household level, including wastewater treatment. These technologies will be necessary for the world to overcome the challenges facing it, he explains, such as climate change and large-scale human migration. Unlike many others, Cloete doesn't find these prospects frightening.

"I have a very optimistic view of the future, I believe in human ingenuity, I believe in human resilience, and I believe we are at the tipping point that will force us into a new world, a new way of thinking and a new way of doing just about everything. And I'm excited about that, I'm excited about the opportunities," he says with a smile.



| DARRELL COMINS |

TOP THREE AWARDS

- Science-for-Society Gold Medal of the Academy of Science of South Africa, 2007
- De Beers Gold Medal of the South African Institute of Physics, 2006
- National Research Foundation President's Award as an A-rated scientist, 2007

DEFINING MOMENT

In my academic career, the recognition of my research achievements by the award of an A-rating by the National Research Foundation has been a defining moment.

WHAT PEOPLE DO NOT KNOW

My broad interests in both the arts and science and the unforgettable experiences from travelling widely and the appreciation of cultures of other countries.



THE FASCINATION OF MATERIALS

Darrell Comins was born in Pietermaritzburg on 10 June, 1942. Attending Merchiston Preparatory School and, later, Maritzburg College, he followed what was then the traditional classics course – English, Latin, history, Afrikaans, mathematics and physical science. With a broad spectrum of interests and a strong creative streak, Comins reflects that he could quite easily have elected to pursue a career in law or the arts. However, he also had a flair for science, and enjoyed the experience of making things. He was particularly adept at building and flying model aircraft, and this was rewarded with a gold medal in the South African Games as well as the Victor Ludorum award at the South African Model Aircraft Nationals. He also built a high-fidelity stereo record player from scratch when these were in their early days. “This was also the era of the rapid development of science in many spheres, and this seemed to offer the best option for me,” he says of his decision to focus on science as a career, citing such developments as the work being done on the Space Programme. Subsequently, Comins enrolled for a BSc in physics and applied mathematics at the University of Natal (Pietermaritzburg), which he obtained in 1962. A year later he completed his BSc (Hons) degree in physics with distinction.

Relocating to the Transvaal, Comins became a PhD student in physics at the University of the Witwatersrand (Wits) in 1964, also working in the latter stages as a temporary lecturer in the Department of Physics. Graduating with his PhD in 1970, he was offered a postdoctoral fellowship at Queen’s University in Kingston, Ontario. Thus, he spent the next year in Canada, returning to Wits in 1971 as lecturer in the Department of Physics. He has remained at Wits ever since. He was promoted to senior lecturer four years later, and in 1981 attained the rank of Associate Professor. During this period, he spent time in the United Kingdom while on year-long sabbaticals – first at the Clarendon Laboratory in Oxford in 1976, and, nine years later, at the Department of Physics of the University of Bath.

Having distinguished himself in his field, Comins was promoted *ad hominem* to the position of Professor of Optical Spectroscopy of Solids in 1990. In 1993, he advanced to the Special List for Professors. In 1994, he was ap-

pointed as Acting Head and subsequently Head of the Department of Physics until 1997. He was also involved with the Schonland Research Centre for Nuclear Sciences at Wits, holding the position of Chairman of the Search Committee for the Chair of Physics/Directorship from 1994 to 1996, and in 1997 serving as the Chairman of its Interim Governing Committee, overseeing the restructuring of the Centre.

In 1997, Wits and the National Research Foundation (NRF) established the Wits-NRF Raman and Luminescence Laboratory as a NRF Facility with Comins as Director. In 2003, he was appointed as Professor of Solid State Physics at Wits, also taking up the role of Chairman of the Materials Physics Research Institute. The following year, he was appointed as Director of the Department of Science and Technology (DST)/NRF Centre of Excellence in Strong Materials (CoE-SM), a position which he held from 2004 to 2007.

The centre was established as a major South African research network hosted by the University of the Witwatersrand, in partnership with MINTEK and the South African Nuclear Energy Corporation (Necsa), as well as four other South African universities, and deals with the prediction, design, evaluation, development and exploitation of strong materials. He remains active in the research and supervision of students as Emeritus Research Professor, a position he has occupied since 2008.

In his productive career as a researcher, Comins has applied his energies to the study and understanding of materials including their structural, vibrational, electronic and defect properties. To this end, he developed laboratories to provide a variety of optical techniques, including optical absorption and luminescence and Raman and Brillouin laser light scattering spectroscopy. These techniques provided the experimental core of his work and were adapted to extreme conditions such as low and high temperatures and at high pressure.

In earlier years, his work was directed primarily towards basic research. He contributed to the understanding of the mechanisms of radiation damage in alkali halides using both experimental and theoretical approaches. His work on radiation effects was expended by using ion beam implantation

of various materials. Studies of fluorite-structured superionic compounds provided important insights into the complex, defect-mediated processes leading to their anomalous high- ionic conductivity.

NEW DIRECTIONS

New directions followed his establishment of surface Brillouin scattering (SBS), extending the Brillouin facilities already unique in South Africa, and permitting the study of surface acoustic waves in opaque solids. These led to the extraction of their elastic constants and hence mechanical properties. Pioneering studies with SBS at high temperatures and high pressures were carried out on several different materials together with his postgraduate students and collaborators. Studies of nanoparticles in different systems were investigated and the temperature dependence of the vibrational modes of single-walled carbon nanotubes was studied.

The award of the CoE-SM and his appointment as Director opened a new chapter in Comins' research work. "Strong materials are those that maintain their distinctive properties such as hardness and toughness, high mechanical strength and stiffness, wear, corrosion or radiation resistance under extreme conditions such as very high or low temperatures, high pressure, adverse wear or chemical conditions or damaging radiation," he explains. "The choice of my area of specialisation has been materials physics which includes fascinating and challenging science which has proved never ending in its scope but also combines extremely important practical aspects and applications," he notes. "For a country such as South Africa with its vast mineral resources these aspects are of great importance." Understanding the nature of these materials is critical to industries such as mining or manufacturing, where the appropriate use and handling of such materials influence the quality, efficiency and financial viability of the end product.


Of this area of study, and the expertise of the members of the CoE-SM, Comins has been quoted as saying, "It is an exciting field in which to work because it brings a range of researchers together, including chemists, engineers, metallurgists and physicists to collaborate on projects that lead to the cross-fertilisation of ideas across disciplines."

These research activities are aimed at improving the materials currently in use by industry, as well as developing new, better-suited ones. The knowledge created through these efforts can be applied to industries within South Africa's borders, as well as globally.

In pursuing these objectives, Comins worked mainly with collaborators and students associated with the CoE-SM. The elastic constants and engineering moduli of materials with high temperature applications were determined with SBS. These included rubidium (a platinum group alloy) and titanium carbide in which both materials are associated with South African mining.

Studies of the elastic properties of thin supported films were initiated by his visit to the University of Kaiserslautern, Germany where he studied the elastic properties of tungsten carbide films using SBS. These films have wide applications as wear-resistant and protective coatings. Comins introduced these techniques and equipment at Wits and produced a number of thin films with practical applications together with colleagues who also developed major film characterisation equipment.

Comins with a colleague and students studied the properties of synthetic polycrystalline diamond used in tools for precision cutting, and in the mining and oil and gas industries. Using Raman spectroscopy the stresses as a function of tool geometry and temperature were measured and fatigue type processes were studied. Three-dimensional mapping of stresses in plastically deformed diamond was achieved.



Comins also studied corrosion processes in iron. Studies were conducted *in situ* using a specially designed electrochemical cell permitting Raman microscopy of the iron surface while statistical methods determined the relative amounts of the individual iron oxides. The results provided new knowledge on composition of the passive film, the role of water and the processes of pitting. In separate studies the inhibition of copper and iron corrosion was carried out with various inhibitors.

Comins has been a keen mentor to his students throughout the years, at Wits and abroad. He counts this interaction with passionate young people as being one of the most satisfying aspects of a university career. He enjoyed the challenge of the classroom scenario, teaching undergraduate students, as well as having put much of himself into the supervision of postgraduate students, particularly those of disadvantaged communities. He has supervised students at Wits from South Africa, Portugal, Ireland, UK, Romania, China, Zimbabwe, Kenya, and Ethiopia and while abroad, mentored students in France and Germany. His students have reaped the benefits of his investment in them, many going on to hold senior positions in their workplaces, with many others receiving awards for the work they have done. "It has been a privilege to watch students develop their knowledge and skills, display their originality and enterprise and their sense of achievement in science," he enthuses. Under his supervision, 21 students have obtained PhDs or MScs, and he continues to look forward to a number of others graduating.

| HOOSEN COOVADIA |

TOP THREE AWARDS

- The Order of the Star of South Africa, Class V received from former President Mandela, 1999
- The AAS Award for Advancing Science, Serving Society, 2014
- The ASSAf Science-for-Society Gold Medal, 2004

DEFINING MOMENT

Qualifying as a paediatrician; the growth and improving quality of my publications after the papers in the *Lancet* on measles – my first solo effort, and on malnutrition and immunity [in which I was a foot soldier to my mentor Prof Smythe] (the paper became a citation classic); studying in India; marriage and my children; the 2000 International AIDS Conference which I chaired.

WHAT PEOPLE DO NOT KNOW

Despite some corroding *bourgeois* proclivities, I remain at heart and in mind, an adherent of equity and fairness in all things meaningful, justice for the poor [the rich often look after themselves very well] and the elimination of poverty, with a deep and abiding distrust of the raw capitalism I have witnessed in SA. I have been fortunate, given the modern trend in transient relationships and marriages, in being in love with my wife for over 50 years. I cannot do without reading contemporary high-quality literature.



TAKING UP THE CRUSADE FOR CHILDREN

Hoosen Mahomed Coovadia, known as “Jerry” to those close to him, was born in Durban on 2 August, 1940. Raised in a Muslim family, Coovadia first attended St Anthony’s, a Catholic school in Durban, and completed his secondary schooling at Sastri College. He credits his mother as having been a great influence in his development. Having been brought up by her businessman father, she often accompanied him on his travels, and was extremely fond of reading – an overriding passion shared by her son. Indeed, at the time, Coovadia recalls preferring literature to science, devouring books from his local library in Brook Street.

Growing up as a person of colour in a South Africa that was then in the throes of apartheid, career choices were limited for pupils excelling at a secondary school level: teaching, law, medicine or commerce. The latter was especially prominent when coming from a background of large family-owned and run enterprises, such as the manufacturing business managed by the young Coovadia’s own relations.

Holding strong political views, the ideals of capitalism and business were distasteful to Coovadia. Therefore, despite his relatives’ best efforts to woo him to the family industry, Coovadia insisted on studying medicine. He spent a year at the University of Natal Medical School, a medical school which had originally been founded specifically for African students, but upon receiving too few applications, enrolled Indian and coloured students too. The campus was directly neighboured by the Wentworth Oil Refinery in a building approaching an army barracks. Finding this environment unfavourable for pursuing his studies, he then exchanged Durban for India. Enrolling at the University of Bombay, he spent two years studying science before being accepted to study medicine at the Grant Medical College (GMC). Places at this prestigious institution were extremely hard to come by and competition was fierce, but fortunately he did well enough in the admitting examinations to be given a place directly into GMC; many South Africans entered indirectly as some places were reserved specifical-

ly for South African students of Indian descent. Here, he became involved in politics, espousing the ideals of socialism. A group of like-minded peers formed the South African Students Association, an overtly political body, and often invited speakers on Indian independence, as well as speakers from the African National Congress (ANC). In this period of his life, he met his wife-to-be, Zubeida Hamed, a medical student a few years his junior (now practising as a dermatologist) and hailing from the Western Cape.

Returning to South Africa, he worked as an intern and medical officer, eventually specialising in paediatrics, which he ascribes to serendipity rather than design. His father, he recounts, was unenthusiastic about his desire to remain at the university to pursue academic medicine, believing that the best doctors entered private practice. Appeasing his family, he joined a three-person firm of private specialists – obstetrician, physician and paediatrician – an experience, he declares, that put him off private health care forever. “Nothing,” he recounts, “could convince me that issues of life and death should be exposed to the vagaries of a so-called free market – which of course is rarely ‘free’.” Resigning abruptly from the practice, he took the first job he was offered at the King Edward VIII Hospital in Durban, where he was strongly influenced by a colleague who was an enthusiastic and efficient paediatrician. A defining time in the trajectory of Coovadia’s career, this is where his commitment to paediatrics was cemented and in 1971, he obtained his Fellowship of the College of Physicians from the South African College of Medicine.

Having become interested in issues around immunity in children, Coovadia furthered his studies at the University of Birmingham, completing his MSc in immunology in 1974. He stayed in the UK for a further year as a research fellow, accumulating further research expertise at the Institute of Child Health in London. Returning to South Africa in the mid-1970s, he took up a post at the University of Natal, earning his MD in 1978, upon which he was promoted to the position of senior paediatrician and lecturer. He was awarded a research grant by the Medical Research Council (MRC), and in 1979 was able to spend the year as a postdoctoral fellow at the Walter and Eliza Hall Institute of Medical Research in Melbourne, Australia.

SOCIAL REALITIES

The social realities faced by South Africa spurred Coovadia on to research problems where a real impact could be made at grassroots level, and his specific area of interest was the subject of immunodeficiency in children – which formed the basis of his doctoral thesis. Throughout his career, he has studied a range of aspects related to these concerns, his early research focused specifically on issues around measles, the manner in which immune responses are affected by malnutrition, and immunisation. The work done by Coovadia in this regard has made a considerable contribution to the field of immunity. The value of his findings was highlighted when they were quoted in the World Health Organisation's (WHO) technical report series on immunodeficiency. Furthermore, a paper co-authored with Prof PM Smythe on immunity and malnutrition has become a 'citation classic', regarded as one of the seminal works on the subject. In order to investigate this area, Coovadia worked on animal models of malnutrition. These studies are extensively quoted in current literature on this topic, including a text by the controversial RK Chandra.

In addition to his work on malnutrition and immunodeficiency, Coovadia has also made a significant contribution in the area of paediatric kidney diseases, nephrotic syndrome in particular. While working with children at the King Edward VIII Hospital, he initiated and continued the implementation of renal biopsy techniques in children. He has spent the last two decades in collaboration with Prof Miriam Adhikari (whom he supervised for her doctorate) as well as Dr Bhimma, and together they have collected and published the largest series of work dealing with nephrotic syndrome in Africa. This included the publication of the definitive description of nephrosis in South African black children.

Also observing illnesses specific to the region in which he was practising, Coovadia undertook much research on local childhood diseases. In this regard, Coovadia has published, among others, on issues such as systemic lupus erythematosus (SLE) and poisoning by impila, a plant that is most associated with traditional herbal medicines in Africa.

He has also been much involved in numerous vaccine studies throughout his career, including work on vaccines for measles and acellular pertussis (commonly known as whooping cough). He has also studied at length the effect of Vitamin A supplements on immunity to measles and other infections.

In 1986, he was made Professor of Paediatrics and Child Health at the University of Natal, where he was later appointed as Professor and Head of Department. Here he was pivotal in assembling a group of dedicated, renowned researchers and scholars in the field. In this time, the seeds for the work which have made him particularly prominent in South African medical research were sown when, in 1989, the first child diagnosed with HIV/AIDS was admitted to his hospital ward. Soon the wards were flooded with similar cases, and Coovadia was forced to re-examine the prevalent stereotypes of HIV/AIDS as affecting only homosexual, white patients. Receiving funding from UNAIDS (the Joint United Nations Programme on HIV/AIDS), Coovadia spearheaded a research group examining the phenomenon of mother-to-child transmission of HIV/AIDS. Much of his subsequent research has built on this foundation, particularly with reference to the context of Africa and developing nations. He has often collaborated with Prof Anna Coutsooudis, another former PhD student. Coovadia has become prominent as an activist in this regard, and influential in the dialogue around related South African policymaking.

Upon his retirement in 2001, Coovadia was appointed as the Victor Daitz Professor in HIV/AIDS Research, and in 2007 took up the post of Scientific Director at the Doris Duke Medical Research Institute of the UKZN. He now holds the position of Director at MatCH Health Systems, dealing with Maternal, Adolescent and Child Health, under the auspices of the University of the Witwatersrand. He maintains close ties to UKZN, where he is Emeritus Professor of Paediatrics and Child Health, and also a Research Associate of CAPRISA – the Centre for the Aids Programme of Research in South Africa.

POLITICAL INTERESTS

In addition to his illustrious career as a medical researcher, Coovadia gained prominence through his involvement in South African politics. In

the 1970s, Coovadia joined the Natal Indian Congress, a party which had been revived by Mewa Ramgobin. Beginning in the Overport branch, he was soon speaking at meetings, going on to join the leadership of the party and being elected Vice-President. He also became a leading member of the United Democratic Front (UDF), where he was part of a delegation to Lusaka, participating in meetings with the ANC prior to the unbanning thereof. He was active in the preliminary discussions and negotiations at the Congress for a Democratic South Africa (CODESA). He sat on the executive of the National Medical and Dental Association (NAMDA), an organisation of progressive doctors established after the complicity by doctors in the security police torture and subsequent death of Steve Biko was revealed. Coovadia, like many others, fell victim to political harassment, and security police bombed his home while his wife and children were inside. Fortunately, they were not harmed. This was not the case with some of his fellow activists and friends. Although he later returned to medicine completely, Coovadia has been active in government, assisting in shaping policies around health care when approached, and has been active in campaigning for the improvement of these policies, especially in connection with the HIV/AIDS pandemic.

Throughout his career, Coovadia has devoted much of his considerable energies to participation in the academic and professional community. He has been part of diverse committees of UKZN, acted as a consultant for UNAIDS on HIV research standards. He is among others a Founder Member and long-serving member of the Council of the Academy of Science of South Africa (ASSAf), a Fellow of the Royal Society of South Africa, an Honorary Lifetime Member of the International Association of

Physicians in AIDS Care (IAPAC), and acts as chairperson for the Steering Committee of the Isisombululo Programme as well as the FPD (Foundation for Professional Development).

In his capacity as an academic, Coovadia taught both at undergraduate and postgraduate levels in medicine, nursing and other health sciences for over 30 years, and was involved in innovation in medical education and training at local and national level.



Having become a world leader in his chosen profession, one thing has remained constant: he still is an avid reader, fond of novels and political accounts which he makes time for every day.

| ANNA COUTSOUDIS |

TOP THREE AWARDS

- ASSAf Science-for-Society Gold Medal Award, 2009
- Nutrition Society of South Africa award for outstanding contribution to nutrition research, 2004
- GSK/Save the Children Health Care Innovation Award, 2015

DEFINING MOMENT

In my first year out of school I had enrolled in pharmacy studies with my goal being that of a typical child of immigrant parents to open a pharmacy and become wealthy and significant. Halfway through the year I had an encounter with Jesus Christ and made a decision to follow Him and His teachings and ways – my goals soon changed and I found myself being uncomfortable with the career choice so I switched to a BSc so that I could help others through the means of teaching and mentoring people less privileged than I.

WHAT PEOPLE DO NOT KNOW

I love dancing even though I have very little rhythm or co-ordination.



GUIDED BY NEEDS

Anna Coutsooudis was born in Durban on 21 September 1952. Upon completion of her schooling, Coutsooudis enrolled for a BSc degree at the University of Natal, majoring in biological science and chemistry. This was followed by an Honours degree in 1974, where she researched leukocyte antigens in vervet monkeys. Coutsooudis went on to complete qualifications in higher education, and spent a number of years teaching biology at high-school level.

Coutsooudis' career as a research scientist began when she joined the University of Natal's Department of Paediatrics and Child Health in 1990 as a research technician. Here she carried out a number of studies relating to immunity and vitamin A (retinol). She researched the impact of vitamin A on immunity relative to a number of conditions, including measles, respiratory disease and HIV. Whilst employed in this capacity, she undertook PhD studies under the mentorship of Prof Hoosen Coovadia and received her doctorate in 1994. Her focus was on the clinical and epidemiological studies of vitamin A in African pre-school children in South Africa, with an emphasis on measles. In 1998, she was appointed as a research fellow and lecturer at the university, attaining the rank of Professor in 2006.

Coutsooudis was responsible for the first international randomised controlled trial (RCT) investigating the relationship between measles-associated morbidity and vitamin A. This study ascertained that children receiving vitamin A had lower measles-related morbidity compared to those children receiving the placebo. These findings informed government policy to administer high-dose vitamin A to children suffering from cases of severe measles.

As an authority on vitamin A, she was appointed as one of four Co-Directors of the South African Vitamin A Consultative Group, formed in 1993. This group aimed to assess the anthropometric, vitamin A and iron status of South African children, as well as considering immunisation and goitre, informing the development of the related programmes by the Department of Health. Surveying numerous pre-school age children, it became evident that a large number of children in poor areas suffered from vitamin A deficiencies. This led to changes in government procedure, recommending

that children should receive vitamin A doses as a matter of routine. She has also acted as an informal advisor to the Department of Health with regard to the development of nutritional policy since 1996, as well as consulting with the World Health Organisation (WHO) on a variety of issues related to vitamin A supplements.

Apart from her substantial contributions in the field of vitamin A research, Coutsooudis has played a pivotal role in trailblazing research around maternal and child health related to the complex issue of Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS). She expanded her research on vitamin A and immunity by investigating its effect on infants exposed to HIV. She conducted the first international randomised controlled trial, testing the effect of vitamin A on morbidity in infants born to mothers infected with HIV. Once again, she showed the beneficial effects of vitamin A, as results indicated that the HIV-infected infants who received doses of the vitamin suffered fewer severe diarrhoea episodes. This influenced government policy, with six-monthly supplements of high-dose vitamin A being administered to all children infected with HIV following the publication of these findings.

In addition, she has been involved in investigating factors contributing to the transmission of HIV from infected mothers to their infants. A major finding with international impact was that she was able, for the first time, to establish that non-exclusive breastfeeding increased the risk of infants contracting the virus from their mothers. This emphasised the importance of exclusive breastfeeding as the norm – a departure from the prevailing wisdom at the time which caused considerable controversy amongst fellow scientists as well as the local community. However, rigorous investigation over a number of years has proven the validity of these conclusions, and these have now been included as part of the international Joint United Nations Programme on HIV/AIDS (UNAIDS) guidelines on HIV and breastfeeding policy. These initial studies have been expanded, as well as auxiliary investigations being undertaken.

As an expert in the field of HIV/AIDS, she has participated in an informal working group on the prevention of mother-to-child transmission of HIV under the auspices of UN/AIDS, as well as being part of a team commis-

sioned by the WHO to prepare a report on the progress of child health and nutrition research and its role in programme development for a special session focusing on children hosted by the United Nations. From 2002 – 2005, she served as a board member of the Child Health and Nutrition Research Initiative of the WHO/Global Forum for Health Research and in 2006, she was elected as member of the Technical Steering Committee of the WHO, Child and Adolescent Health unit.

In collaboration with researchers from the University of California, she has participated in extensive research on methods which could be used to make breastfeeding safer for HIV-exposed infants. Together, they have pioneered the use of flash-heating of breast milk to render it safe for consumption – a practice which is now accepted in South Africa and is taught in curricula of the medical and health sciences. Continuing her work on breast milk pasteurisation, she collaborated with the Programme for Appropriate Technology in Health (PATH) and Rohit Chaudri, a computer engineer from the University of Washington who developed an Android application system called FoneAstra to enable low-cost breast milk pasteurisation. This consists of a temperature probe which connects to a mobile device while heating breast milk, and the probe is linked to the app on the mobile device, guiding health workers through the process of pasteurisation thereof. Another boon for developing regions is that no electricity is required for this process (beyond that of having a charged handset battery) allowing it to function in areas where there is no, or restricted, access to electricity. This method renders the breast milk safe for consumption within a matter of 17 minutes, as opposed to the numerous hours it would take to pasteurise the milk using industrial equipment. Funding from the Bill and Melinda Gates Foundation has made it possible to use this low-cost equipment to set up five Human Milk Banks in small public hospitals in KwaZulu-Natal (KZN).

In December 2015, Coutsooudis' team from the University of KwaZulu-Natal (UKZN) was the recipient of the GlaxoSmithKline (GSK) and Save the Children Health Care Innovation Award, enabling them to scale up their low-cost pasteurisation systems in community settings. The need for such systems has also been expressed by other African countries and Coutsooudis and her team will be using the grant money to set up Human Milk Banks in Ethiopia and Cameroon.

The affordability of the device enables babies in communities with limited resources to gain the maximum nutritional and consequent immune benefits from breastfeeding, giving infants access to breast milk where it may not have been possible before. "The only time when rich and poor children are on an equal footing is in the first six months [of life]," Coutsooudis said upon receiving this award, explaining her passion for the project. "This is because the breast milk of poor mothers and rich mothers is exactly the same."

HAVING A DESTINY

Coutsooudis has been guided directly by the most pressing needs of the community in which she works, not only in her work as a researcher, where her contributions have had tremendous impact, but also as a humanitarian. Together with her husband, Nick, she is active in the ministry of their church, and is driven to fundamentally improve the circumstances of children affected by HIV/AIDS. In order to expand this reach, she established a non-profit organisation (NGO) called iThemba Lethu (which means "I have a destiny" in Zulu), where she has acted in the capacity of chairperson from 2000 to 2015. This NGO addresses the needs of children, particularly those in the KZN region, in a number of ways. One programme deals with caring for children orphaned as a result of AIDS, while another entails running a HIV prevention programme. Offering a holistic school and other interventions, the programme reaches school pupils as well as parents and caregivers and empowers them to strengthen family structures, thereby supporting positive changes in behaviour in the fight against HIV/AIDS. Through these interventions, iThemba Lethu has been able to make a substantial impact in these communities.

Another notable feature is that she established the first community-based breast milk bank in South Africa, the iThemba Lethu Breast Milk Bank in Durban. The donated breast milk enables infants either abandoned by HIV-positive mothers or orphaned as a result of HIV/AIDS, to be fed and cared for. Having received funding from United Nations Children's Emergency Fund (UNICEF) for this endeavour, the first of its kind worldwide, she documented its processes in order to offer a model for best practice. In order to improve the functioning of similar banks and to ensure that inter-

national standards are upheld, she was involved in establishing the Human Milk Banking Association of South Africa (HMBASA). She was elected as its first chairperson in 2008, in which capacity she has assisted in developing guidelines for operating breast milk banks in South Africa.

DOMINUS ILLUMINATIO MEA

Coutsoudis has been prolific in research and holds to the motto of Oxford University “*Dominus illuminatio mea*” – the opening words of Psalm 27, The Lord is my light – she attests to the fact that God has illumined the pathway of her scientific endeavours. Her list of publications is comprehensive, numbering over 120 articles in peer-reviewed journals, as well as a number of reports, books and conference papers, as well as having served as a reviewer for many others. In addition to this, she served on the editorial board of the *International Breastfeeding Journal*, the *Maternal and Child Nutrition Journal*, and *PLOS One*. Her engagement, however, has not been limited to the academic milieu – she has frequently contributed to articles and blogs in popular media, also speaking at numerous events, to raise awareness of the issues around breastfeeding, infant health and HIV/AIDS. Beyond her accomplishments as a researcher and as an advocate, Cout-soudis has been active in developing students and aspiring researchers. At undergraduate level, she has taught medical students about breastfeeding, as well as teaching research methodology, while her postgraduate instruction has expanded on public health policy, nutrition and prevention of mother-to-child transmission of HIV. She has supervised several students, from various international institutions and locally, at Masters and PhD level. This includes the supervision of a number of post-interns from the Medical Research Council (MRC). Her passion for education is also evident in the developmental initiatives she has undertaken in her role as a humanitarian, where training and empowerment at all levels form an important part of the interventions undertaken by iThemba Lethu. Similarly, she has been involved in the conception of a variety of resources for use by HIV counsellors and local community health workers. Internationally, she has been involved in courses and seminars in the United States, Canada and Sweden, amongst others.

She is a member of a number of professional and academic bodies, including the Nutrition Society of Southern Africa, and is an elected Member of the Academy of Science of South Africa (ASSAf), as well as being a Fellow of The World Academy of Sciences (TWAS).

In 2005, she was recognised by civil society, through her selection as one of the country's top 100 achieving women featured in a book titled: *Valued Citizens Initiative Art Book, Celebrating Women through the Eyes of our Children*.

In an advisory capacity, she has been active at national government level, as well as participating in a variety of prestigious International Advisory Committees. She is a member of the PATH, Technical Advisory Group on International Human Milk Banking.

Coutsoudis pays tribute to the many colleagues with whom she has worked, especially her previous Heads of Department, Professors Coovadia and Adhikari, who created an affirmative and supportive environment for her to do her research work. She also acknowledges the important role of the many lay counsellors and research assistants with whom she has worked on community health programmes. She believes she learnt much from them in understanding the importance of health being more than just medical intervention and the importance of the spiritual, and psychosocial elements of health. She comments “if we wish to see progress in health and development in South Africa, we are going to have to work together not only across racial divides but more especially across hierarchical divides where we see each other as equally important – the doctor and nurse as important as the lay counsellor and the mother – where there is no rank and we all work in a compassionate and caring way towards one goal of improving the health of our society”.

As a passionate follower of Jesus Christ, she believes His teachings have transformed her life and given her the desire to serve others and improve the lot in life especially of women and children. She is looking forward to the next season of her life as she has fun with her five young grandchildren and invests in them the teachings of Jesus – “Love the Lord your God with all your heart and your neighbour as yourself”.

ROBIN MICHAEL CREWE

TOP THREE AWARDS

- Gold Medal of the Zoological Society of South Africa, 2001
- Gold Medal for Meritorious Service from ASSAf, 2013
- Harry Oppenheimer Fellowship Award, 2012

DEFINING MOMENT

The defining moment in my career was when I decided to undertake my PhD studies on ant chemical communication. This led to a lifelong exploration of social organisation in ants and honeybees.

WHAT PEOPLE DO NOT KNOW

A passion for flying fixed-wing aircraft.



THE COMPLETE BEEKEEPER

Robin Michael Crewe was born in Johannesburg on 18 February 1946. Growing up on a farm in Mpumalanga, his secondary and tertiary education was undertaken in Natal. He matriculated from Kearsney College in 1963 going on to enrol at the University of Natal, Pietermaritzburg where he completed his undergraduate and Masters studies.

Majoring in chemistry and biochemistry, he was awarded a BSc (Agric) degree in 1968, and in 1969 received his MSc (Agric) *cum laude* specialising in biochemistry. Crewe then relocated to Athens, Georgia in the United States for the duration of his doctoral studies.

While furthering his entomological studies at the University of Georgia, he worked as a research and teaching assistant. He developed his interest in chemical communication and social organisation in social insects, particularly honey bees and ants, while living in the United States. The work reported in his PhD was well received, and in 1971 he was awarded his doctorate with distinction. Returning to South Africa later that year, Crewe was appointed as lecturer in the Entomology Department of his *alma mater*, the University of Natal. He remained there until the University of the Witwatersrand (Wits) offered him the post of senior lecturer in the Department of Zoology. Consequently, he moved to Johannesburg in 1976.

His time at Wits was fruitful, and he soon distinguished himself in a number of roles. Crewe was promoted *ad hominem* to Professor of Zoology in 1984 and, the next year, became the Head of the Department for the first time (he would reprise this role in 1991). He was appointed as Deputy Dean of the Faculty of Science in 1986. A period followed where he served as Chairperson of the School of Biology, and in 1994 he was elected to the position of Dean of the Faculty of Science. He also served on the Council of the university, having been elected by Senate to do so.

While working at Wits, he founded the Communication Biology Research Group, of which he was the Director for the decade spanning from 1986 to 1996. Studying the chemical communication systems of honey bees, a

major focus of the research undertaken by this unit was the investigation of pheromonal communication of honey bees.

When his term as Dean ended, Crewe bid Wits *adieu*, and moved to the University of Pretoria (UP) in 1997 to take up the position of Dean of the Faculty of Biological and Agricultural Sciences. He served in this capacity for six years, at which point he was promoted to the position of Vice-Principal of Research and Postgraduate Studies. His responsibilities in this position were manifold, with the Faculty of Engineering, the Built Environment and Information Technology (EBIT), the Faculty of Natural and Agricultural Sciences, as well as the Gordon Institute of Business Science falling within his ambit. Added to this scope was the oversight of all postgraduate studies and research activities undertaken at the university, as well as the international office, library services and the research support office.

An additional role he fulfilled was in the Southern Education and Research Alliance (SERA), where Crewe represented UP. In his function as Relationship Manager, he was responsible for the everyday operations, and was also expected to report back to the Council of UP on progress which was made by the alliance. Within this alliance, he was a member of the feasibility group as well as the strategic management team. Furthermore, he functioned as a joint co-ordinator of numerous working groups, including the Forestry and Forest Products Biotechnology, Food and Food Technology, Molecular Modelling, Sustainable Rural Development and Water Research groups.

ACADEMIC ADVANCEMENT

Outside his university responsibilities, he has been a member on a variety of panels and committees in the realm of academic advancement together with some of the key role players in South African education policy, including the National Research Foundation (NRF), the Department of Education (DoE) and later the Department of Higher Education and Training (DHET), Higher Education South Africa (HESA). He has also served as Chairperson of the South African Agricultural and Veterinary Science Deans Committee, and on the Agricultural Research Council's ANPI-UP Management Com-

mittee and the Plant Protection Research Institute – UP Nitrogen Fixation Unit Committee.

While excelling in his role as university administrator, he continued to participate in research activities. He was made Extraordinary Professor in the Department of Zoology and Entomology of UP. Here he undertook research as a member of the Social Insect Research Group (SIRG), which extended the research programmes originally undertaken at Wits in the Communication Biology Research Group. After a ten-year period in the role of Vice-Principal, Crewe retired from this position. He remains at UP, where he is the Director of the Centre for the Advancement of Scholarship, as well as continuing in his capacity as an active researcher.

His distinguished research career as an entomologist has been devoted to the study of social insects, particularly ants and honey bees. His particular field of expertise in behavioural ecology relates to social organisation and chemical communication prevalent in social insect colonies. Another branch of the research undertaken is the assessment of indigenous populations of honey bees to ascertain the impact of honey bee diseases.

UNDERSTANDING THE BEE

His work on honey bees is particularly significant in the wake of the widespread debate on the crisis faced by bee populations worldwide. Honey bees play a critical role, not only as producers of honey, but also as pollinators of crops. It has been widely reported that numerous honey bee populations across the planet are declining rapidly, facing potential extinction in certain regions of the world. In a special issue of the journal *Apidologie*, some of the potential developments were listed as colony collapse disorder, winter losses and weak bee colonies. Such a “doomsday scenario”, as Crewe has termed it, could have far-reaching ecological impacts and affect the livelihoods of beekeepers, as well as impact on agricultural production, which in turn could threaten food security. Crewe's work has led to an understanding of a variety of aspects related to the ecology of these insect colonies which may be utilised to combat such eventualities. He has studied in detail the self-organising social systems which are characteristic of social insects, detailing the underlying mechanisms through which this

organisation is achieved. A related aspect of this focuses on pheromones as a means of communication, and the associated regulation of reproduction in honey bees.

Another area in which Crewe has conducted extensive research, is the phenomenon of social parasitism in honeybee populations. Within this field, Crewe has studied the interactions between hosts and parasites, as well as the co-evolution of these, and also the relationship between the phenomenon of parasitic worker bees and the practice of beekeeping. In addition to these areas, he has investigated environmental factors relating to the conservation of honey bees.

Crewe has found that the largest number of wild honeybee swarms are to be found on the African continent, meaning that most genetic diversity is also to be found here. A thorough study of these African populations could provide a strong basis for conservation efforts in the Northern hemisphere and Latin America, regions where honeybee populations are particularly endangered. Furthermore, African honeybees are genetically more resistant to diseases than their counterparts in other regions of the world. There is potential for slowing the decline in honeybee populations on other continents, if some of these more resistant genes could be introduced.

His status as one of the world's foremost honeybee experts has been recognised worldwide, and as a result he has been invited to a variety of institutions as a visiting scholar. While in the Netherlands on sabbatical leave in 1979, he was temporarily appointed at the Rijksuniversiteit te Utrecht in the Laboratory of Comparative Physiology. In 1988, he had the opportunity to spend a period of three months as *Professeur Invite at the Université Paris-Sud* at Orsay, France. He has maintained strong working relationships with colleagues in France, with numerous collaborative efforts over the years. He also spent some time in Bremen, Germany where he was a German Academic Exchange Service (DAAD) research fellow at the University of Bremen in 1997. His research association with the Molecular Ecology Research Group led by Prof Robin Moritz has been of long duration and has resulted in numerous collaborative visits and the exchange of post graduate students. His most recent research collaborations have also included academics from France, Germany and Switzerland.

As supervisor or co-supervisor, Crewe has seen 15 MSc students to graduation, and 15 PhD students, with more in the pipeline. In addition, he has had five foreign PhD students complete a portion of their studies in his laboratory, and has had ten postdoctoral fellows work in his laboratory. He has published widely, with in excess of 130 articles appearing in peer-reviewed journals and has served as editor of the *Journal of the Entomological Society of Southern Africa*. He has been a member of the editorial boards the *Journal of the Entomological Society of southern Africa*, *African Entomology*, *Insectes Sociaux* and the *South African Journal of Science*. Currently, Crewe is a member of the International Scientific Board of *Apidologie*.



He has been elected as a Fellow to the Royal Society of South Africa, the Royal Entomological Society of London, The World Academy of Sciences (TWAS) as well as the African Academy of Science (AAS). He has served as President of ASSAf, of the Network of African Science Academies (NASAC), and of the Entomological Society of southern Africa.

In recognition of his contributions to his field, Crewe has been awarded a number of honours and he holds a B-rating from the NRF.



Crewe has been key to the development of professional registration of natural scientists through the South African Council for Natural Scientific Professions, where he is a registered professional natural scientist. Throughout his career, he has been closely involved in a broad spectrum of scientific societies. He is a Founder Member of the Academy of Science of South Africa (ASSAf). He is a member of the South African Association for the Advancement of Science, the Entomological Society of Southern Africa, the Entomological Society of America, the International Society of Chemical Ecology, the Southern's Beekeeper's Association, the Zoological Society of South Africa and the American Association for the Advancement of Science.



| GEORGE EKAMA |

TOP THREE AWARDS

- National Order of Mapungubwe (Silver), 2013
- International Water Association Project Innovation Award, 2012
- Water Institute of South Africa/Water Research Commission/Council of Scientific and Industrial Research Stander Memorial Lecture, 2004

DEFINING MOMENT

Learning the basics of engineering from my father as he was 'tinkering' in our family garage.

WHAT PEOPLE DO NOT KNOW

I don't do social media and I don't like emails. It's such a weak form of communication. A real discussion requires being there in person. For deep information exchange (and doing good research) you need to spend face-to-face time with other people.



SAVING SA'S PRECIOUS WATER

Clean water is a basic human requirement, but in an arid country like South Africa keeping it flowing, can be a challenge. Professor George Ekama has made it his life's work to keep the country's taps running and clean.

From tackling algal blooms in dams and rivers by preventing pollution from municipal and industrial wastewater to biological sulphate reduction in acid mine drainage, Ekama has been at the forefront of global technological innovation in the water sector.

His specialty is using biological processes to remove and recover waste products from water, including the water itself. Over the years, he has published over 170 research papers on these subjects and contributed to several International Water Association reports on sludge management and wastewater treatment. His advice is sought-after internationally, and he collaborates with international colleagues on solutions, such as using seawater to flush toilets, in water-stressed cities.

So valuable are Ekama's insights that his employer of 40 years, the University of Cape Town (UCT), does not want him to leave despite him having reached retirement age in 2014. In 2015, he has been busy setting up a new laboratory in his department.

He enjoys the work, but he hankers for more time to think. Modern communications technologies that mean that you can keep in touch with anyone, from anywhere, at any time, are a nuisance and a distraction, he says. "I miss the days when messages came in brown paper envelopes, and no one expected a reply for a month afterwards – there was time to think."

EARLY LIFE AND TRAINING

An engineer by training, Ekama's entry into academia was somewhat accidental. Before joining UCT as a researcher, he worked in the Cape Town harbour. Even after joining the university on a contract basis it took him more than a decade to get a permanent position.

He was born in the Netherlands in 1949, but his family moved to South Africa (SA) when he was six years old to escape Europe's post-war economic slump. In the Netherlands there were also great floods in the early 50s that led the Ekama family to seek a better life elsewhere.

From the start, engineering was in Ekama's blood. His father was an engineer, as was his grandfather, uncle and brother. As a child, Ekama learnt the tricks of the trade from his dad in the family garage where Ekama Sr, a mechanical engineer, would take things apart to see if he could put them back together again – things like the family car, for example.

Ekama enrolled at the University of Cape Town (UCT) for a Bachelor's degree in engineering in the late 1960s. He chose civil engineering because it was the easiest course to get a bursary for. At the time, there were massive intakes on the course to train engineers for the apartheid government's major infrastructure projects, including airports, roads, dams and harbours. At school, he hadn't been a star pupil by any stretch. In fact, with his grades – a couple of As and Ds, and an E – he wouldn't be accepted into UCT today, he admits.

However, he loved Cape Town, which was far from where he'd grown up on the other side of the country, both geographically and culturally. "For me coming to Cape Town was like going to San Francisco. Everyone was a hippy."

After graduating with honours in 1972 he got a job on the container quay in the Cape Town harbour. But he didn't enjoy the job. "We worked ridiculous hours in order to match the tides, and we didn't get paid overtime. I also didn't like the monotony of the work, so I thought that in order to keep my neurons from dying out I should enrol in some evening classes."

ACADEMIC BEGINNINGS

It was at the postgraduate evening classes that Ekama first met Professor Gerrit van Rooyen Marais, who was the Chair of Water Resources and Public Health Engineering at UCT's Department of Civil Engineering. Marais'

main research interests at the time were in municipal water and wastewater treatment. This caught Ekama's interest. When his contract was up with the contractor at the harbour, Ekama resigned and came to work at Marais' laboratory at the Professor's invitation to do a Masters degree.

The laboratory was at the time wrestling with a major problem facing wastewater treatment in SA. The country's new sewage systems, the activated sludge process, was using design criteria from the United States, which were not appropriate for SA where people use much less water leading to more concentrated wastewater flows.

Another huge and related problem was eutrophication – algal blooms in SA's rivers, lakes and dams driven by the release of nutrients like phosphates and nitrogen from wastewater, emerged in the late 1960s. The Water Act of 1956 required that all water taken from a river had to be put back to safeguard the supply downstream. But up until the mid-70s the workhorse of wastewater treatment was the trickling filter which was unable to remove the nutrients except by chemical means. Chemical removal of phosphorus could not be contemplated in SA due to its exacerbation of the growing salinity problem from acid mine drainage, unless one is going to completely reclaim the water. Finding biological nitrogen and phosphorus removal methods with the activated sludge process became a national priority.

For his PhD and throughout his early career Ekama worked with Marais on developing models of biological processes for removing nitrogen and phosphorous from wastewater. Their work fed into an international modelling effort that resulted in the international standard models known as "Activated Sludge Model Nos 1 and 2".

After completing his PhD in 1978, Ekama remained a soft-funded staff member of the UCT Department of Civil Engineering until he finally got a permanent position in 1992 when his PhD supervisor and mentor Professor Marais retired.

The lack of job security throughout the 80s and early 90s (soft-funded staff depend on external project income to pay their salaries) didn't really bother him. Marais' group had dependable funders in the South African Water Research Commission, established in 1972 and the forerunner of the National Research Foundation. In fact, Ekama enjoyed being on a temporary contract as it allowed him to focus on research since he was spared from having to spend a lot of his time teaching undergraduates and dealing with departmental administration.

From 1992, Ekama's duties changed. His teaching load was increased and he was suddenly head of the small research group. Having been part of a national effort that developed the biological nitrogen and phosphorus removal activated sludge system (there is a nutrient removal configuration called the UCT process) he joined the national effort on dealing with the salinity problem: how to reduce sulphate in acid mine drainage, but by biological means. This problem opened his work on biological sulphate reduction using sewage sludge as the energy source, which has brought him full circle back to municipal wastewater treatment arising from seawater toilet flushing, a project he is working on with colleagues in Hong Kong, where seawater toilet flushing has been practised since 1957.

MAJOR WORKS

Ekama co-edited and co-authored a seminal book on biological wastewater treatment that was published in 2008 by the International Water Association. The book became a best-selling work of reference, and it has been translated into Korean, Spanish, Arabic and Chinese. The book was written during a challenging time in Ekama's career. In 2006, his group shrunk from five to one: his long-time colleague Dick Loewenthal retired; resignation of a research officer; former PhD student Sven Sötteman left to start his own consultancy; PhD student Ashley Muller was killed in a car accident at the Rondebosch Common a month before submission; and long-standing research officer Professor Mark Wentzel was permanently medically boarded. With Ekama being Head of the Department of Civil Engineering from 2003 to 2007, and with more undergraduate teaching

duties, he had very little time for research – a time during which his wife Janet and daughter Katie renamed him ‘absent professor’. “It was a very difficult time. I am extremely grateful for their patience and understanding – whenever more time had to be found, they were the ones who were short-changed. Any success is also thanks to them and is also theirs.”

In 2008, Ekama stepped down as head of his department and was able to concentrate more on research again. In 2010, his laboratory at UCT was demolished to make way for a new building. This further freed up Ekama’s time as he no longer had to deal with the administration and fundraising for his own lab. Instead, he used colleagues’ labs in Padua, Delft and Hong Kong, where he has spent some productive research leave periods.

In Hong Kong, Ekama got to work on an intriguing new problem. The city, which is severely water-constrained, had been using seawater to flush toilets since 1957. But seawater corrodes the sewerage pipes, a problem called crown corrosion. In Hong Kong, scientists have pioneered the use of urine separation toilets to ameliorate the problem of crown corrosion in the seawater-flushed system. Small urine-treatment plants can be used to remove micro-pollutants such as pharmaceutical residues, which are not recovered in conventional treatment plants. The system also saves energy. Urine separation toilets are among the technologies that Ekama thinks can help SA as it faces its next big water-related crisis. “The problem is that our population is growing, not just in number but economically. When people earn more they will use more water. So economic growth as a result of empowerment will result in greater water consumption.”

The challenge, he says, is not technology – it is changing people’s mind sets and how they engage with water and their waste. At the moment, he says, waterborne sanitation and water supply systems have been designed purely for the comfort of the user. Any change from the current system is likely to cause some form of discomfort. All of us need to become more aware of our environmental impact and learn to embrace greater com-

plexity and some discomfort to minimise it. However, the benefit would be a cleaner and more sustainable society for all to enjoy.

Over his career, Ekama has received several recognitions and prizes. He is one of only a few environmental engineering professors listed on Thomson’s 2002 – 2013 ISI Highly Cited website, listing the scientists whose work has attracted the most citations from colleagues worldwide.

A devout Christian, he believes it is his duty to use his competency and skills to serve society and future generations. He attributes his success to providence and hard work, to being in the right place at the right time. “As environmental engineering grew explosively from the 1960s, I grew with it. I did not plan to be successful; that I have become so is a surprise to me also – it grew out of going to work every day, paying attention to detail, meeting deadlines, doing one’s best and serving others.”

Personally he says it does not bother him a lot whether he succeeds or fails. “I do what I do as best as I can because I believe that’s the responsible way of employing my gifts and talents,” he says. However, an engineer to the core, he gets a kick out of problem-solving. Problems engineers try to solve are real, it brings a focus and urgency to the work.

He sees himself as a steward for the skills and knowledge he has amassed throughout his career, and he believes one of his most important duties has been to pass this on to future generations.

While he has been offered jobs abroad that he has turned down, he believes it has had little to do with how his life turned out. The best of me and the worst of me follow me wherever I go, he says. “I’ve loved it. It’s been amazing. If you said to me, George, why didn’t you take the job overseas? I don’t think I would have done any better there, and the need is greater here.”

| GEORGE ELLIS |

TOP THREE AWARDS

- Templeton Prize, 2004
- Star of South Africa Medal, 1999
- Fellowship of Royal Society (London), 2007

DEFINING MOMENT

Deciding to write *The Large-Scale Structure of Space-Time* with Stephen Hawking.

WHAT PEOPLE DO NOT KNOW

I have won trophies for both flying (the Stanley Damp Trophy) and gliding (Cape Gliding Club).



THE DOWN-TO-EARTH COSMOLOGIST

For somebody who has spent much of his time thinking about the structure of the universe, Professor George Ellis is remarkably down-to-earth. Over the past half-century his work has not only probed the nature of space-time, but his knowledge of mathematics has helped solve crises facing South Africa, such as providing housing for the poor.

A Professor (now emeritus) at the University of Cape Town (UCT), Ellis is one of South Africa's most distinguished scientists. He has co-written a bestselling book on general relativity theory with Stephen Hawking, whom he met at Cambridge as a research student. A deep thinker, he has won great prizes for his work on the interplay between science and religion. A big-hearted man, he has given much of his winnings to charity.

He has been instrumental in building up cosmology and applied mathematics in South Africa. This has had a direct impact on the country's ability to attract great astronomy projects such as the Square Kilometre Array radio telescope. Now in his 70s, he remains a defender of science and an influential international voice in debates about the philosophy of science.

EARLY YEARS, CAMBRIDGE AND APARTHEID

Ellis was born in Johannesburg in 1939 to socially conscientious parents: His father was a newspaper editor, and his mother helped found the Black Sash anti-apartheid movement. He went to boarding school in KwaZulu-Natal, where he matriculated with top marks for science. After matriculating he joined his parents who had moved to Cape Town, where he enrolled for a degree at UCT.

At university Ellis started out studying architecture, since a career counselor at his school had suggested he studied a subject that combined art and science. But he quickly realised that he did not have the visual imagination needed to make architecture his career. After a year he switched to major in physics and mathematics. Varsity was not just academics for Ellis, however. A sporty student, he represented the university in fencing, rowing and flying, and spent much time climbing.

After graduating from UCT with his BSc in physics (with honours and distinction) in 1960, Ellis went to Cambridge in the United Kingdom to embark on a doctoral degree. He once more started out on a dual track, combining mathematics and philosophy – as well as some intercollegiate rowing for his college, St John.

Ellis' choice of subjects at Cambridge was influenced by a book he had read before leaving South Africa by Sir Arthur Eddington, a British astronomer and physicist born in the 19th century. "The stuff of the world is mind-stuff," Eddington had written in his book *The Nature of the Physical World*. He argued that we, as observers of the world, cannot be separated from our interpretation of what we observe. This struck a chord with Ellis, and influenced his choice to study relativity theory at Cambridge.

Ellis got his PhD from Cambridge in 1964 aged only 25 years. For the next ten years he would be based mostly at Cambridge, but with stints at the Enrico Fermi Institute in Chicago and the University of Texas, both in the USA, and the University of Hamburg in Germany. At Cambridge, Ellis worked with Stephen Hawking, a fellow postdoc at the time. In a move that would help propel Ellis' career forward, the two wrote a book together: *The Large-Scale Structure of Space-Time*, published by Cambridge University Press in 1973. The book was called "a masterpiece, written by sure hands" by the journal *Science*, and by late 2015 it had attracted nearly 10 000 citations and had been translated into Russian and Chinese.

Ellis returned to Cape Town in 1974. He did so partly for personal reasons (his mother was there and he missed walking on his beloved Table Mountain) and partly because he wanted to "do something on the social scene" in South Africa. Ellis took up a professorship in applied mathematics at his alma mater at the height of apartheid. The move influenced his research direction profoundly. "I think if I had stayed in Cambridge I would probably have done more distinguished work in relativity and gravitation. But I wouldn't have broadened out the way I have done. I am very happy to have done that," he says.

As head of applied mathematics Ellis had a lot of freedom to choose what he wanted to research. In his inaugural lecture on 11 September 1974 at

UCT, Ellis stated: “There is no such subject as applied mathematics”. Rather, he said, it is an ‘attitude’ of numerically investigating issues using mathematical techniques. He soon began working on real-world problems such as providing low-income housing for the poor. His 1976 book *Squatters of the Western Cape* written with colleagues from UCT and the South African Institute of Race Relations and his book with David Dewar on *Low-Income Housing Policy* ended up infuriating the Minister of Community Development, but also influencing housing policies in the country.

Ellis took a firm stance against the apartheid regime. He joined the Quaker Service Fund and the Institute of Race Relations. He took part in protests against government laws, and although he never did anything illegal the security police kept tabs on him. He noticed this especially when he got involved in a project that looked at ways to improve peoples’ lives in black ‘homelands’ using appropriate technology. The closest he got to being ‘in trouble’ with apartheid authorities was when he publicly argued that the security agencies had intentionally stoked the violence that followed Nelson Mandela’s release. “That could have been dangerous,” he says.

SCIENCE, RELIGION AND TESTABILITY

Ellis remained in his professorial post at UCT until retiring in 2004, whereupon he took up an emeritus position. In addition to his work on cosmology he has spent a lot of time thinking about the philosophy of science and the relationship between science and religion. In 1996, he published a book with Nancey Murphy, an American Professor of Christian philosophy that discusses the ‘moral nature’ of the universe. He has also written about the concepts of free will and causation. He believes that all science is done with an assumed philosophical basis – whether the scientist him or herself wants to acknowledge it or not.

One of the central tenets of Ellis’ own philosophy is that all systems – even humans – are more than simply the sum of their parts. He doesn’t believe that systems can be understood by understanding each of their smallest constituents. Other forces, such as intentions, thoughts, and social conventions, influence systems ‘from the top down’. This puts him at odds with others who argue, based on recent breakthroughs in molecular biology

among other things, that humans are basically just machines without a purpose driving them.

Thinking of humans just as a collection of atoms and cells can never explain what humans do, or why they do it, he wrote in the journal *Nature* in 2005. “There is no physics theory that explains the nature of, or even the existence of, football matches, teapots, or jumbo-jet aircraft. [...] Even if we had a satisfactory fundamental physics ‘theory of everything’ this situation would remain unchanged: physics would still fail to explain the outcomes of human purpose, and so would provide an incomplete description of the real world around us.” (*Nature*, Vol 435, 9 June 2005, p.743).

In 2004, Ellis was awarded the Templeton Prize, which rewards academics whose research affirms life’s spiritual dimension. The prize is given out every year, and was at that time the largest annual research award in the world – bigger even than the Nobel Prizes given out by the Royal Swedish Academy of Sciences. In the year that Ellis won the award it was valued at £795 000 or more than US \$1.4 million. He accepted it from the hands of Prince Philip, Queen Elizabeth II’s consort, at a ceremony in Buckingham Palace. Specifically, he received it for his work balancing the rationality of evidence-based science with faith and hope, a view that the prize-givers judged had been influenced by his experiences during South Africa’s political transformation.

Ellis put half the prize money into a trust that will be paid to UCT after his death. The other half he gave away; R1 million to the Association for Education Transformation, which provides extracurricular teaching to disadvantaged students in Cape Town.

More recently, Ellis has been engaging in what some call “the battle for the heart and soul of physics”. Some aspects of physics are pushing up against the boundaries of what is testable in the real world. For instance, some proponents of string theory say that although the theory may not ever be testable, it should be accepted as solid physics as it is the only theory that is capable of unifying all the fundamental forces in physics – electromagnetism, the weak and strong interactions, and gravity.

"These guys have been saying that 'our theories are so good that we don't have to test them'," Ellis says. But to do so would, to his mind, be tantamount to science taking a step backwards by a thousand years. "The whole point of the experimental method was that you had to test things," he says.

In the December 2014 edition of *Nature*, Ellis and a colleague, Joe Silk, wrote about the problem of exempting speculative theories from experimental verification as a major threat to science. Especially at the same time as politicians and others were questioning key scientific results in topics from climate change to evolution. The testability of science, they wrote, is its only defence against such attacks. (*Nature*, 18 – 25 Dec 2014, Vol 516, pp. 321-323) The article received a great deal of attention, and fuelled a global debate on the issue.

A CLASS ACT

Ellis is living proof that world-class science can come from South Africa.

In addition to his accolades, he has shown that a theoretical science degree can be utilised for the good of society and humanity. The work on low-income housing in the Western Cape in the 1970s was just the beginning. Since then, he has worked on education, especially the mathematics curriculum, and has provided advice for national science policymakers. He has co-edited a book on substance abuse and neuroscience, published by UCT Press in 2010. In 2009, then UCT Chancellor Graca Machel capped him for an honorary philosophy degree, calling him "one of the most distinguished scholars, past or present, this country has produced".

He considers his important legacy as having built up cosmology and astronomy in South Africa. He is proud that many of the people who run departments in these fields across the country went through his department at UCT. He has supported efforts to get astronomy facilities built in the country. Instruments such as the Southern African Large Telescope based in Sutherland and the Square Kilometre Array radio telescope, an international mega-array of dishes that will have its centre in the South African Karoo, were both made possible partly due to the intellectual capacity Ellis

has helped to build in the country. He believes such large-scale, expensive projects are necessary to keep up the scientific morale of the country. "People always ask why should one do these things in a country like South Africa." To him the answer is the same as the one Winston Churchill supposedly gave

when he was asked during the Second World War why he wasn't cutting funding for the arts to boost the war effort. According to legend Churchill replied: "Then, what are we fighting for?" (The veracity of this has been called into question, but it's a good quote nonetheless.)

"This is the same," says Ellis. "The purpose of having these facilities is to show that Africans and South Africans can achieve scientifically at a world-class level. It's really important for the country to be able to say that it isn't a backwater."

| JACOBUS (KOBUS) ELOFF |

TOP THREE AWARDS

- Science-for-Society Gold Medal of the Academy of Science of South Africa, 2012
- Gold Medal of the South African Association of Botanists, 2013
- MT Steyn Prize of the *Suid-Afrikaanse Akademie vir Wetenskap en Kuns*, 2015

DEFINING MOMENT

Being treated by senior scholars with support and generosity.

WHAT PEOPLE DO NOT KNOW

"I'm a dedicated Christian, I believe that where there is love and caring, God is present. But, perhaps people don't know about my regret. There was a time in my life when I was selfish and arrogant. I hope that I have changed. Now, I follow the advice of Ralph Waldo Emerson who said 'Happiness is a perfume you cannot pour on others without getting some on yourself'."



JACK-OF-ALL-TRADES ACHIEVES SUCCESS

Twenty years ago, when the Academy of Science of South Africa was established, Jacobus (Kobus) Nicolaas Eloff, then already in his mid-fifties, was invited, as Director of the National Botanical Gardens, to become a founding member of the Academy. However, once his CV had been reviewed, Eloff's founding membership was declined on the grounds that his scholarly achievements were "rather meagre".

Twenty years later, Professor Eloff is an ASSAf Member and Gold medallist; an Honorary Life Member and Gold Medallist of the South African Association of Botanists; a council member of the *Suid-Afrikaanse Akademie vir Wetenskap en Kuns* (SAAWK); an internationally recognised leader in his field; an NRF B-rated scientist (until 2021); and the author or co-author of over 250 peer-reviewed scientific publications – with 20 more already accepted for publication. This incongruity is probably due to his nature as an archetypal *Lévi Straussian bricoleur* – a man who has, both practically and intellectually, built almost everything he has achieved from what he has found available to him: changing, adding and developing his skills and research foci as his academic and practical career developed.

Eloff was born in Westdene in Johannesburg, attended the three-teacher Boskop Primary School after his family moved to a smallholding in Honeydew, moving on to Helpmekaar High School and then to the Florida Dual Medium School once a school bus service was instituted. He had to cycle a round trip of 20 kilometres so that he could play rugby and cricket. An average student, however, he says that his children once found a school report from an encouraging teacher in matric who wrote "Why not try for 60% next term, Kobus?"

His first year at the Potchefstroom University for Christian Higher Education (PU for CHE – and now North-West University) was filled with trepidation: his school performance had been far from stellar; he was from a working class background; neither of his parents had completed high school; and he was the first person in both of his parental families to attend university. Not surprisingly, he found the university environment to be unfamiliar – even

strange and threatening – and without any family members to whom he could turn for support in this new world. In 1956, PU was a small university – and he notes that the only student in the entire university who had an old car was Andre P Brink – who was already writing for local magazines and earning enough to buy and run the car.

It is most significant, however, that this strange and daunting environment was made first tolerable, and then a happy adventure, by the kindness and support he received from the academic staff with whom he had contact. He was encouraged and, as a result, flourished, and was then further encouraged to extend his course work and to diversify his areas of research. Originally intending to major in chemistry and physiology, the Dean of Science offered him a deal: change your majors to chemistry and botany, and the university will provide a bursary to do an Honours degree in botany. This was the first defining moment in his life: that senior scientists would treat him as they did – with support and generosity despite (or, perhaps, because of?) his background. Those experiences shaped much of his subsequent teaching and research career, his attitude and approach towards his own students and fostered his life as a *bricoleur*.

In 1959, Eloff graduated with a BSc degree in botany and chemistry and, a year later, with a BSc Honours degree in chemistry. In 1961, with his Honours degree completed, he was appointed as a Professional Research Officer by the Agricultural Research Institute (ARI) for the Highveld region and, a year later, he completed an MSc degree in chemistry.

BIRTH OF A BRICOLEUR

Here the role of *bricoleur* began to take shape – his work in the ARI encouraged him to study for a part-time BSc Honours degree in botany, which he completed in 1963 and, in the following year, was appointed as a temporary, stand-in, lecturer in plant physiology and biochemistry at the University of Pretoria (UP).

While lecturing at UP, he completed accreditation for a second Masters degree, this time in plant biochemistry. With two Honours degrees (one in

chemistry and the other in botany) and two Masters degrees to his credit, Eloff completed the DSc degree (in plant biochemistry) and in 1968 returned to his *alma mater* in Potchefstroom as a lecturer in botany. Ever the *bricoleur*, he soon made his way to the University of the Free State, which lured him away from PU to become a Professor of botany (with a great deal more to offer than botany) where he remained for 13 years. During this period he spent a year on sabbatical with his wife and two daughters in Israel and, a few years later, a year in the USA working on the toxic cyanobacterium *Microcystis aeruginosa*.

The need for change led him to Kirstenbosch where, in 1983, he became the Executive Director of the National Botanical Gardens and Harold Pearson Professor of Botany at the University of Cape Town (UCT). In this position, he was primarily a manager, and needed new skills. Eloff completed a certificate in executive management at Stellenbosch University (SU) in 1984 (a year after becoming Executive Director) in order to develop his managerial skills and, in 1986, was awarded a certificate in strategic management. At about that time he started the initiative and was appointed by the Minister for Environmental Affairs and Forestry to merge the National Botanical Gardens (NBG) and the Botanical Research Institute to become the National Botanical Institute (NBI) and advise on changes to the Forestry Act to enable the amalgamation. He was then appointed as Director of Research and moved from Cape Town to Pretoria. At the same time, however, he became an Honorary Professor at SU and UP and at the Rand Afrikaans University (now the University of Johannesburg).

Eloff found this to be a challenging appointment: priorities in the NBI were changed, most of the available funding was directed to the gardens, while he struggled to find funds for research. And so, in 1994, at the age of 55, he decided to take early retirement from the NBI, thinking that his qualifications and managerial experience would ensure him a new position. But in 1994, 55-year old white men were not necessarily considered to be suitable employees. He applied for 20 positions and was turned down in all 20 instances.

In addition to starting a new consultancy, Pro Scientia, he decided to become a builder on the basis of having previously built two houses. He

bought a very difficult steep plot and began building a new house, engaging, as his construction staff, unemployed but skilled people who were looking for work. Then, in 1995, when the house was not yet completed, he was appointed as senior lecturer in pharmacology at UP to teach in the area of medicinal plants (yet another example of bringing his tool bag into use). In this position, he found himself primarily teaching pharmacy students (and later students who had studied in other fields) and, at the same time, spent many hours teaching himself. Through this process, he became acquainted with the research in the field – and it was due to this self-motivated learning that he published two papers dealing with what he discovered to be gaps in the field. Between them, those two papers were cited almost 2 000 times.

By this time, Eloff was nearing 60, and in 1999, he had to retire in line with the UP human resource policy at that stage. He was, however, still supervising many postgraduate students, and the Vice-Principal at UP at the time, Prof Theuns Erasmus, made funding available so that he could be re-employed on the basis of a fixed-term contract that would allow him to continue his supervisory and research responsibilities. After rationalisation of faculties at the university he moved with his group to the Faculty of Veterinary Science at Onderstepoort where he was later promoted to the position that he now still holds at the age of 76, Research Professor, Faculty of Veterinary Science, at UP. As he puts it, his one year fixed-term contract has been renewed 17 times to date.

During the course of his 54 years as a scientist – working in research and management – he has published (as author or co-author) some 250 scholarly papers with more than 200 in the field of phytomedicine. He has also published more than 90 conference abstracts since 1998 and has made almost 400 conference presentations in most cases jointly with his postgraduate students. He has also registered six patents (between 2004 and 2014) with a further two pending. He is or was a member of 20 local and international scholarly associations, for many of which he has served as the Chair, Vice-Chair or a board member. Eloff has also worked jointly with colleagues, as a teacher and researcher, with 20 international universities and commissions. Underscoring his international reputation and the ability

to make the most of what is at hand are the invitations he has received to serve as a reviewer for 266 different scientific journals. He was an Elsevier top reviewer in 2010 and has also been the editor of six volumes of the *Annals of Kirstenbosch Botanical Gardens* and several books. He is presently section Editor of *BMC Complementary and Alternative Medicine*, editor of the *Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie*, a member of the editorial panel of the *South African Journal of Botany*, and of the *African Journal of Traditional Complementary and Alternative Medicine*. He turned down invitations to join editorial boards of 32 other scientific journals.

Asked to identify his most important contributions to scientific knowledge, he identified the amalgamation of the NBG and the NBI, the production of the first *African Herbal Pharmacopoeia* and his decades as editor of scientific journals and several highly cited papers.

Eloff sees this support to students as a reflection of his own experience as an underprepared, estranged student in his first days at PU. He sees himself in his students, even at their relatively advanced level, as young people who could best make progress if they received the understanding, gener-

ous support that he received when, as a 20-year old, he entered a world both foreign and potentially uninviting. For the past 13 years, it has been his aim to make students from all over Africa who are new to postgraduate studies feel that they are at home and supported in an unfamiliar university and facing unfamiliar, even new, scientific languages.

Happy with the honours and awards that he has received, he is quick to point out that it is the work of his students that is rewarded, and that in Ecclesiastes, Solomon is recorded as saying: "I saw that the swiftest person does not always win the race nor the strongest man the battle...but it is all by chance, by happening at the right place at the right time". One of his favourite quotes summarising his life is also from Ecclesiastes: "To enjoy your work and to accept your lot in life – that is indeed a gift from God. The person who does that will not have to look back with sorrow on his past, for God gives him joy".

Although his two daughters and his five grandchildren are overseas, his life is filled with joy especially because he and his wife, Christna, are now even more in love than when they were married 52 years ago.



| BERNIE FANAROFF |

TOP THREE AWARDS

- One of the first MeerKAT antennas was named after him by Deputy President Cyril Ramaphosa, 2015
- National Order of Mapungubwe, 2014
- Named as the Ambassador of the Year by the Afrikaans newspaper *Die Burger* and the Cape Chamber of Commerce, 2012

DEFINING MOMENT

Receiving an Isaac Newton Studentship to do his PhD at Cambridge University, and meeting his wife, Dr Wendy Vogel.

WHAT PEOPLE DO NOT KNOW

"Most things," he says. Fanaroff does not like exposing his personal life to the media. Although he enjoys addressing people, he does not relish the spotlight.



DIRECTING THE WORLD'S LARGEST RADIO TELESCOPE

"I've always been better at thinking visually than in numbers or equations," Fanaroff states when explaining how the Fanaroff-Riley classification system of distant radio galaxies came about.

He was interested in the monochrome computerised contour plots of radio galaxies scattered around the offices shared by the graduate students, and started noticing some specific patterns.

"The more powerful radio galaxies and quasars had bright blobs at the ends of their jets; the weaker radio galaxies didn't have bright blobs," he explains.

The two different kinds became classified as Fanaroff-Riley type II and type I respectively.

"Julia introduced some discipline into the work," he adds matter-of-factly about his collaborative paper with fellow PhD candidate, Julia Riley, in *Monthly Notices of the Royal Astronomical Society* entitled Morphology of Radio Sources of High and Low Luminosity. This is still the most widely used way to classify these very large radio galaxies and quasars.

The paper was just 'a sideline' to his actual PhD work on how populations of radio galaxies and quasars change through the history of the universe.

THE UNION MOVEMENT

On completing his PhD in 1976, he returned to South Africa and the University of Witwatersrand (Wits) as a junior lecturer in physics. Fanaroff says his conscience made him complete his doctoral studies first, before starting to "work on some way of opposing apartheid and improving the lives of South Africans".

"The [PhD] qualification was what I wanted to do, and enjoyed, and after that I felt I had to do something else."

He rates his parents, Ike and Fanny Fanaroff, as the major mentors in his life. "Everything I learnt about having a social conscience, interacting with people, not being arrogant, being open and honest, I learnt from them." This also included a strong dose of humanist ethics, and a reverence for learning, reading and knowledge.

In South Africa he met his partner of 36 years, Dr Wendy Vogel, a specialist in child and adolescent psychiatry. He rates meeting her as one of the defining moments of his life. They met through friends. After two years at Wits, Fanaroff was starting to consider a postdoctoral opportunity in England because he had not yet found an initiative that he wanted to pursue. Then a chance meeting connected him with some of the mobilisers of the emerging African union movement in Durban and Johannesburg, and so began his life as a unionist.

During the next 17 years, Fanaroff was not able to stay abreast of research in radio astronomy. It also became too expensive to subscribe to the necessary journals. Instead, he helped set up the Metal and Allied Workers' Union, which in 1987 merged with other unions to become the National Union of Metalworkers of South Africa (NUMSA). He was to become amongst other things a National Secretary of NUMSA.

Nowadays, it is hard to imagine a time when unions did not have an active say in South Africa, but getting them off the ground in the 1970s was difficult. Fanaroff believes this part of history should be written up comprehensively, before it disappears from public view.

"Working in the unions was enjoyable, but the times were very difficult," he adds. "I would not like to live through it again."

LIFE AS A CIVIL SERVANT

If there's one thing he wouldn't mind having another go at, though, it is the short-lived Reconstruction and Development Programme (RDP) of the 1990s.

In 1994, he became Deputy Director-General in the Office of former President Mandela and was Head of the RDP Office under Minister Jay Naidoo. He also set up the project management service, which later moved to the National Treasury.

"Working with President Mandela was a unique opportunity," Fanaroff notes.

He remembers it as a frenetic time, with everyone in the country wanting to meet and work with the RDP team. Mandela closed the office after two years.

During the years between 1997 and 2000, he served as Deputy Director-General in the Ministry of Safety and Security. He worked alongside Minister Sydney Mufamadi, and then Steve Tshwete. During this time, he served as Chair of the Integrated Justice System Board and the Steering Committee for Border Control. These projects aimed to streamline business processes and information technology in the criminal justice system and border control.

In 2000, Fanaroff set up his own consulting business outside of government.

BIDDING FOR THE SKA

And then the Square Kilometre Array (SKA) happened, and Bernie Fanaroff came back to radio astronomy as Project Director of SKA SA.

The words "dogged", "quiet", "undemonstrative" and a "great negotiator" that are often used to describe him, came into play.

After giving up radio astronomy for so long, he came full circle back into the field, even though very much in a managerial role.

Of course the SKA wasn't his idea. Prof Justin Jonas of Rhodes University (now Associate Director of SKA SA) and Dr George Nicolson, founding Director of the Hartebeesthoek Radio Astronomy Observatory, presented a proposal to Dr Khotso Mokhele, President of the National Research Foundation and Dr Rob Adam, then Director-General of the Department of

Science and Technology (DST). (In 2016, Adam would follow in Fanaroff's footsteps as SKA SA Project Director.)

The original small group of SKA SA team members has now grown to almost 250 people.

As always, Fanaroff is quick to acknowledge the team effort that went into the successful bid process and now even more so in the planning and execution phases. One of the first MeerKAT radio telescope antennas does carry his name, however.

The precursor 64-dish MeerKAT, to be completed in 2017, will eventually be integrated with 133 other dishes to form the first phase of the SKA array. The construction of this first phase of the array in South Africa and the low-frequency array in Australia is expected to cost the international SKA Organisation 650 million Euro. The cost of Phase Two will depend on the design, to be done in 2019. It will eventually also include about 2 500 dishes across South Africa and South Africa's eight SKA partner countries in Africa. This array of dishes will be an interferometer and will be the most sensitive radio telescope in the world. Scientists will be able to look back into the history of the universe to when the first stars formed.

"I am expecting our African scientists to win a Nobel Prize or two from the science to be done with it," states this Visiting Professor in Physics at Oxford University and a Fellow of the Royal Astronomical Society.

At the launch of the first MeerKAT dish, Fanaroff said in the *Business Day* newspaper: "It shows we can do the best technology, the best engineering in Africa. We deliver what we say we are going to deliver. And we are going to do (great) science. If I were a lot younger, I'd want to work on this project, I'd want to win a Nobel Prize using this telescope".

WORK ETHICS

Fanaroff gains immense pleasure from working with dedicated people. At events he is often the person everyone wants to speak to and learn from, but who would much rather observe from the sideline, keenly aware of the dynamics happening around him.

"The most enjoyable part of this job has been to work with our team in the project, all outstanding people, and, in particular, the young people who want to learn more and are excited about the project."

That said, he adds: "I've always had the attitude that I work as part of a team, and that everyone is an equal. With the proviso that decision-making isn't always democratic – I'll make the decisions, I am the manager".

So why did he take on so many big challenging jobs?

"I've always found challenges very interesting, and once I start working on one, I want to complete it."

"And to be successful, of course."

"Being able to do things and contribute, that's what I always liked," Fanaroff summarises his take on work. "It's like watching sport – I would rather play it than watch."

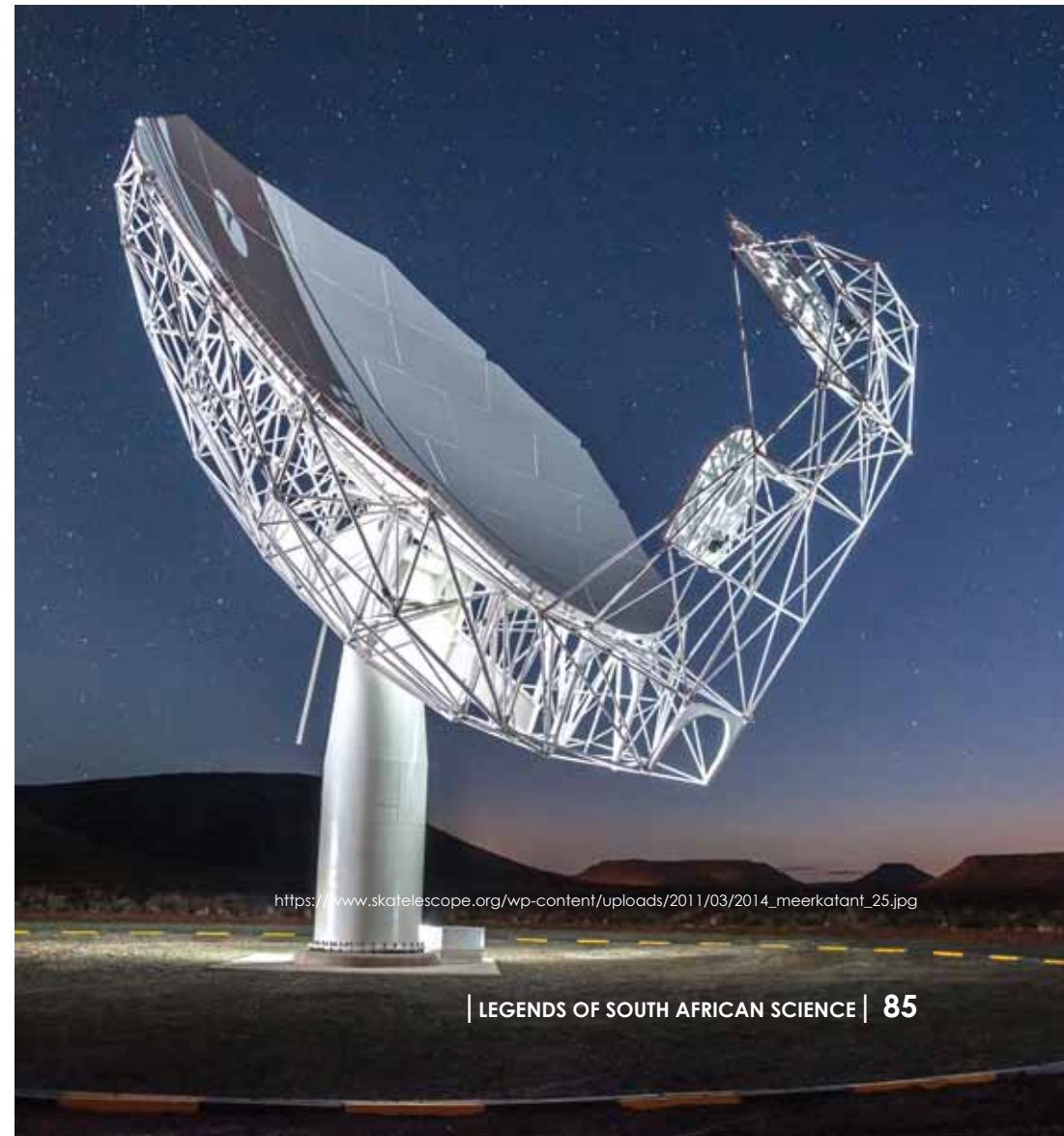
After retiring at 68-years old at the end of 2015, Fanaroff stays on half-time in the SKA SA project as an adviser, ready to assist where needed. "I'll see what else is interesting to do for the other half of my time," he adds. He does hope to play more tennis – a game he hasn't had time for during the past 40-odd years.

About his retirement he says: "I want to slow down, I don't want to have to work hard all the time. Equally, I don't want to do nothing. I will get bored and die".

He'd like to be remembered as someone who inspired people, particularly younger ones, to aim for things that might sometimes seem unrealistic but can eventually be successful.

Above all, however, Bernie Fanaroff will be remembered as the man who brought the largest scientific project to South Africa, and changed the scope of SA science and the possibility ingrained in the country.

As the National Order of Mapungubwe citation reads: "He served in all these positions with the single focus of making South Africa stand out in the global community".



https://www.skatelescope.org/wp-content/uploads/2011/03/2014_meerkatant_25.jpg

| JILL FARRANT |

TOP THREE AWARDS

- Erma Hamburger Award from the EPFL-WISH Foundation, 2015
- L'Oreal-UNESCO Award in Life Sciences (Africa and Arab States), 2012
- DST Distinguished Woman in Science Award, 2010

DEFINING MOMENT

When she was on stage giving the acceptance speech for the L'Oreal-UNESCO Awards in Paris, and realised quite emotionally how her life had culminated into that one moment.

WHAT PEOPLE DO NOT KNOW

She has a new moon, a cross and a phoenix tattooed onto her shoulder, symbolising her faith, new beginnings and opportunities.



THRIVING AGAINST ALL ODDS

Prof Jill Farrant's life merges with water. To be more specific, she's occupied by the ability of a rare few so-called resurrection plants to seemingly die off when none of this life-giving source is available, only to bounce back within hours once a few drops come their way.

She was born in the summer of 1960, during a time when the Vaalwater district in Limpopo where the Farrant family farm, Hartebeespoort, is still located, experienced a particularly severe drought. Her birth on 5 December coincided with very heavy rains, which subsequently broke the drought.

"The employees on the farm decided I was the bringer of rain, and gave me my African name of Mapula, meaning Mother of the Rain," remembers the South African Research Chair in the field of systems biology studies on plant desiccation tolerance for food security at the University of Cape Town (UCT).

Mapula isn't the only nickname of this multi-award winning Professor and mentor to many. When she appeared in a local television series featuring iconic South Africans, she was called the "Rain Queen". And when she was celebrated as a 2012 L'Oreal-UNESCO Laureate in Life Sciences, her photograph on one of the billboards in the streets of Paris honouring the winners was dubbed "The Queen of Africa".

"Weirdly enough, when I go up to the family farm to visit, it rains," she adds with a mischievous smile in UCT's Department of Molecular and Cell Biology. Here she keeps a small plastic container with resurrection plants handy, to show visitors who are somewhat incredulous about the Lazarus ability of her chosen subjects.

CHILDHOOD YEARS

Farrant was born more than a decade after her brother or sister, and grew up quite alone on their farm (now called Culmpine). Still, it was a time of discovery and wonder, which transformed her into a keen naturalist.

One such discovery was a *bobbejaanstert* (*Xerophyta retinervis*) growing on some flat rocks near the river where she loved to play. She noted how particularly dry and dead it looked. Then the rains came. When she again passed that way days later Farrant's nine-year old self noticed that the plant had almost miraculously revived.

It was 1970, a year before the first paper about resurrection plants was to be published in scientific literature.

Farrant was keen to tell her hardworking father about the phenomenon, but he didn't believe her. She then wrote about it in her diary. It was during one of only two times in her life that she had tried to keep up such an endeavour, she says. The other time was during an around-the-world yacht trip during which she very precisely plotted out the subject of her subsequent PhD research project.

The childhood diary entry would have been lost into oblivion if it wasn't for her beloved niece and nephew's mischievousness. They discovered it packed away among other books and dared each other to investigate it further – as children do.

Remorse made them own up, though. In the process, Farrant read her long-forgotten scribbles again, only to realise how as a mere youngster she'd already made her very first observation of a resurrection plant.

"I see a plant at the age of nine, and I write about it in my diary. Why?"

"I am spiritual," she answers herself. "When I look back at my life and the things that made me make the choices I did and led me to a place where I am now, I realise there must have been a plan for me."

STUDENT YEARS

Farrant initially considered becoming a doctor like her paediatrician brother, but opted for marine biology after staying with a school friend's family on the Solomon Islands during her matric holidays. The warmer waters of South Africa's east coast lured her into studying it at the then University of Natal.

In 1986, this *cum laude* student who majored in biology won the first of her many research awards: the South African Association for the Advancement of Science's Medal as her university's top Masters student, as well as the Junior Captain Scott Memorial Medal for the best MSc thesis in the country. She similarly won the South African Association of Botanists Bronze Medal for the best botanical PhD submitted in 1992 and that Society's Silver Medal for excellence in botany in 2007.

These culminated in her receiving a UCT research chair in 2007, an A-rating from the National Research Foundation and the Harry Oppenheimer Fellowship in 2009.

While studying in Durban she met her mentors, the husband-and-wife team of Norman Pammenter and Pat Berjak. They taught her how to be expansive yet practical in her research. "They showed me what is possible, despite of me," acknowledges Farrant, who was recognised for her own mentorship abilities and as a role model to biologists worldwide through the EPFL-WISH Foundation Erma Hamburger Award in 2015.

Norman was very practical about what one needed to do to get results. He'd make her take apart pieces of equipment so that she could learn how to use them properly.

"Pat taught me to think big, not to be scared, to use lateral thinking, and to follow my dreams even when they were impractical at times," says Farrant, who has over the years seen 30 MSc and 20 PhD students graduate, and currently has 18 postgraduate students under her wing.

It was Berjak who also introduced Farrant to recalcitrant seeds, the subsequent topics of her MSc and PhD research. These so-called wet seeds are produced by, among others, coffee plants, amaryllis and clivias, and cannot dry out or be frozen to store and conserve them as can be done with 94% of all other seeds. In the 1980s, these seeds that germinate immediately after being released from the mother plant were "brand-new phenomena" to science, and Farrant became the first South African student to investigate their workings.

A very short stint at the Institute of Oceanography in Stellenbosch to work off her Masters bursary made her realise she wanted to be "more than just a pair of hands for someone else" and to do original thinking.

After obtaining her PhD in 1992, Farrant spent a year in the National Seed Storage Laboratory of the American Department of Agriculture, thanks to a postdoctoral bursary from the Foundation for Research Development.

EARLY YEARS AT UCT

Logistics, and a desire not to follow so very precisely in her mentors' footsteps, resulted in a serendipitous career change to study extremely drought-tolerant plants.

When she started lecturing in botany at UCT in 1993, it was difficult to get hold of enough samples to continue her research on recalcitrant seeds. Plants producing them are not typical of the Western Cape and researchers only have a window of a few weeks per year during which to work on these unstorable seeds.

She was reminded of a paper she had read during her PhD years – the one published in 1970 on resurrection plants. Since then, she has used her knowledge about seeds that cannot dry out to understand plants that survive without water contained in or around them.

Most plants die off once they lose about 60% of their water content. "A plant that can lose all its water yet live is absolutely unusual," stresses Farrant, whose work on bio-engineering drought-tolerant plants and pasture grasses as part of efforts to increase food security have since been funded through fellowships from the Royal Society of South Africa, the Harry Oppenheimer Memorial Trust, UCT and The World Academy of Sciences (TWAS). "Everything on this planet is made up predominantly of water, all life actions happen in water and loss of water causes death – except for resurrection plants."

To be precise, there are only 135 higher order angiosperm plants worldwide typically growing in extreme environments that can do so. The num-

ber goes up to 320 if some lower order plants such as algae, mosses and lichens, are included.

Around 260 genes involving many different pathways help a plant to be desiccation tolerant. Farrant's group has identified some potential "tipping point" factors which turn these critical gene pathways on. Once this occurs, subcellular and especially biophysical changes are initiated that ultimately bring about metabolic quiescence. Once irrigated, the plants rejuvenate within one to three days. Some experience a brief growth spurge, as if to make up for lost time.

Farrant's vision is simple: to replicate this extreme genetic drought-tolerant ability in important crops, so that they too can survive without water yet thrive once it does become available. This will make it unnecessary for farmers in drought-stricken areas to have to sow new seeds for grazing and maize after each dry cycle.

"Yes, the subsistence farmer may be delayed in harvesting his crops, but when it rains again the plants can start growing from where they were," she explains.

She believes the chemical protection that resurrection plants enjoy during these constant dry periods could also be useful for medical purposes. The design company Giorgio Armani, for which Farrant consults, already uses extracts from resurrection plants in one of its leading cosmetics.

LAZARUS WOMAN

Over the years she has featured widely in the media, which has prompted yet another series of nicknames such as "Resurrection Woman" and "Lazarus". These refer to what Farrant calls her "chequered history". For years she was a functional alcoholic, and nearly died three times. Once was because of a serious kidney stone, another was due to an alcohol-induced incident. In another, she slipped on a wet surface, banging her head severely, causing a subdural brain bleed, which ultimately left her without any sense of smell or taste.

None of these experiences has stopped her from treading in uncharted territory, and receiving the respect of her peers and students alike. She has published more than 110 peer-reviewed articles in top journals, authored or co-authored 14 book chapters, fulfilled many editorial and academic responsibilities, and has participated in peer and grant reviews for various national and international grant agencies. She sits on the jury of international award-granting committees such as the Agropolis Foundation and the TWAS, and serves as Jury President of the L'Oreal-UNESCO sub-Saharan African Women in Science Fellowship Programme.



"From the word go people said I was mad, that what I'm working on is too complex," she grins with a certain amount of satisfaction.

She likes to think that she will be able to achieve the research goals she has set herself within her lifetime, yet realises that much is funding-dependent. She trusts that those she has helped train and mentor will be able to carry her flag after she retires. "I never say never."

| WIELAND GEVERS |

TOP THREE AWARDS

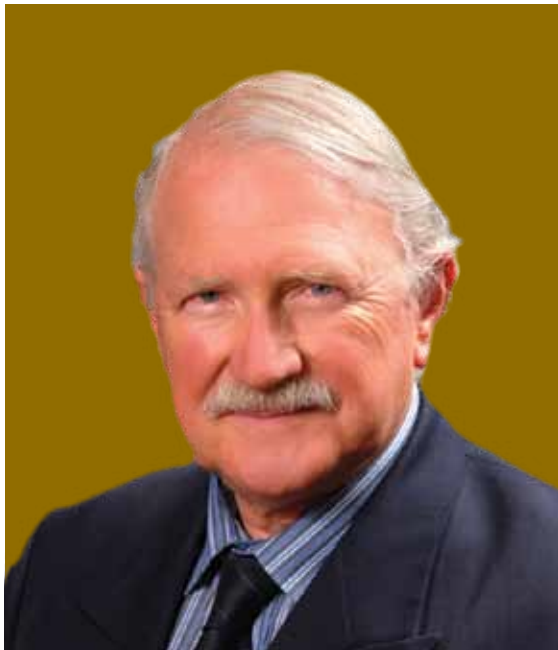
- Rhodes Scholarship, 1962
- Honorary doctorate in science (DSc honoris causa), 1998
- Special Meritorious Service Gold Medal by the Academy of Science of South Africa, 1998

DEFINING MOMENT

I was programme director at Mamphela Ramphele's formal inauguration as UCT's Vice-Chancellor in 1996. When President Mandela took up his position at the podium to deliver his address, he paused for a very long time before speaking. I was the only person (out of the huge audience) who knew that the President was conflicted between his extraordinary sense of courtesy and the fact that he didn't know my name, and therefore could not formally acknowledge my presiding role! This moment captures my lifelong avoidance of publicity, nearly always a mover and shaker but happiest out of the limelight.

WHAT PEOPLE DO NOT KNOW

I have been guided throughout my life by the German concept of 'Bildung' (roughly translatable as the full realisation of one's human potential), which comprises two components: 'Ausbildung', the fullest and never-completed development of all one's own talents or capacities, and 'Anbildung', the unending acquisition of as much knowledge as can be gained about everything in the world. Falling short of these lofty ideals is less of a problem than not having them in the first place.



INSTITUTION-BUILDER OF NOTE

In 1970, a 32-year-old Wieland Gevers faced a big decision: To stay in North America, taking up a prestigious tenured Associate Professorship at the leading Canadian university, or to return to his native South Africa. The Canadian job involved setting up a research laboratory in a famous institute in Toronto.

Gevers chose to come home, even though the job on offer to him in South Africa – a senior lectureship with a small grant at the University of Cape Town (UCT) – was a considerable step down by comparison.

But to the young father, it made perfect sense. Having spent the last eight years of his life learning from two Nobel Prize winners – Hans Krebs at Oxford University in the UK, and Fritz Lipmann at Rockefeller University in New York – Gevers knew what an 'overseas' science career had to offer. But he felt that North America, though full of opportunities, was an overfilled pond where he would be a small fish. In South Africa, he reasoned, he could be a bigger fish with the ability to pursue a more varied career.

Forty-five years after his return, Gevers is known as one of the 'elder statesman' of South African science – an institution-builder, academy-founder and policy-shaper. He has acted as a pioneer in cardiology and muscle research, creating and building strong research centres in these fields – the last and biggest being UCT's Institute for Infectious Disease and Molecular Medicine (IDM). A talented administrator and mediator, he also played a leading role in founding or revitalising several of South Africa's major academic bodies, including the South African Society for Biochemistry and Molecular Biology (SASBMB) and the Academy of Science of South Africa (ASSAf).

But many of Gevers' creative and organisational gifts came as surprises to himself, and he says his most important life lesson is this: Do not be daunted by what you don't know about yourself yet, but capitalise fully on the things you already excel in and build on that in new fields. Also, be careful to make assumptions about what you can and cannot do until you try – some talents only reveal themselves when the right opportunity arises.

THE EARLY YEARS

Gevers' early childhood was far from easy. Growing up to German parents in the old Transvaal during World War II, his family was ostracised for their 'enemy' heritage. People would throw stones at them, or cross the road to get away. Wieland was the fourth child in the family, and spoke German at home. He matriculated with six distinctions from his high school in Nigel on the East Rand, and his excellent grades won him a place and a scholarship to study medicine at UCT.

At university, Gevers was a talented and extramurally active student (he edited both the university's rag magazine and the medical school's student research journal in his fifth year). He received the gold medal in 1960 for his first-class degree, and was also singled out as UCT's overall top graduate that year. After graduating, his internship included spending time at the Red Cross War Memorial Children's Hospital assisting Chris Barnard, the cardiac surgeon who famously performed the world's first heart transplant at Groote Schuur Hospital in Cape Town, in pioneering operations on newborn babies.

During his internship, Gevers realised that a career in clinical medicine was not for him. He had developed an interest in medical science, and won a coveted Rhodes scholarship to study at the world-renowned Oxford University in the UK. Before leaving for Oxford, he spent six months at UCT on a research fellowship under Professor Eugene Dowdle, sharpening up his laboratory and chemistry skills.

Even so, when Gevers arrived at Oxford he was aware that his knowledge of chemistry remained weak. He spent many lonely hours in the library of Balliol College, quietly swotting to catch up. In just one year he completed the Honour School BA, graduating in 1963, and was offered a postgraduate position in the laboratory of Hans Krebs, who had won the 1953 Nobel Prize in Medicine for his discovery of the cellular respiration cycle that bears his name.

Gevers once more felt out of his depth in Krebs' lab. But he was surprised to find an ally and mentor in the Nobel Laureate, who like Gevers, had also

started out as a medical doctor. Krebs told Gevers: "Don't worry about the things you haven't formally learned. The most important thing is that your work habits, picked up as a doctor, are first class." This put Gevers at his ease. What is more, Krebs had been born in Hildesheim, Lower Saxony, and they often spoke German with each other.

During his PhD, Gevers literally poured his own blood into his research. Having developed a new method for measuring oxygen uptake in isolated tissues, he drew a pint of his own blood to prepare an enzyme needed to keep the carbon dioxide level constant while measuring oxygen uptake, and Gevers received praise from the legendary German biochemist Otto Warburg, another Nobel Laureate, who toured Krebs' lab during a visit to Oxford to receive an honorary degree.

Gevers graduated from Oxford with both a Masters and a PhD in biochemistry in 1966. By then, he had married his wife, being the first Rhodes scholar to do so during the fellowship, and sired two children. The same year, he received a Helen Hay Whitney Fellowship to become a postdoc at Rockefeller University in New York in the USA. Once more he made a substantial switch in the focus of his work. At Oxford he had studied metabolism. In New York he would do research on molecular biology.

He once more joined the lab of a famous scientist: Fritz Lipmann who had shared the 1953 Nobel Prize in Medicine with Krebs for the discovery of coenzyme A, which plays a key role in metabolism. Lipmann – another German-speaker – put Gevers to work studying the molecular mechanisms of how antibiotics are made. It was here that Gevers really cut his teeth on benchwork – this was before labs were highly automated, and Gevers performed over 10 000 lab tests in a single year.

Gevers' work at Rockefeller contributed to the discovery of how antibiotics are generated in bacteria and fungi using multi-enzyme complexes capable of organising the process of biosynthesis on their surfaces. He received the honour of presenting the results of the lab's research to an eminent audience that included James Watson, one of the co-discoverers of the

DNA molecule. This was one of the high points of Gevers' scientific career. However, life in New York wasn't only about science. It was here, during his brief revolutionary phase (it was 1968 after all) that Gevers grew his trademark moustache that since then has adorned his upper lip.

RETURN HOME

By the end of his postdoc, in 1970, the world of science lay at Gevers' feet. He had cut his teeth on world-class research, mentored by some of the most famous people in his field. But it was at this time that the rubber band connecting him to his home country began to stretch. Gevers turned down a job at a Canadian university setting up a new research laboratory and went back to UCT, his wife and children in tow.

After a few months at UCT, Gevers realised he had made a mistake. The job was too parochial, the funding too constrained, for him to feel that he was fulfilling his destiny. Thankfully, he was headhunted by Stellenbosch University (SU) as a Research Professor and Director of a Medical Research Council (MRC) Unit in molecular and cellular cardiology; this grew in a few years into a large new Department of Medical Biochemistry.

The move was not far in geographical terms. SU's medical school is located in Tygerberg, on the northern outskirts of Cape Town. However, culturally, the move was significant. At UCT, Gevers had been reared in the English-speaking, outward-looking academic tradition. At Stellenbosch, an Afrikaans bastion, Gevers caused some friction with the administration by bringing many young English-speaking postgraduates from UCT and elsewhere to come work with him in his department.

As if bringing English into the labs wasn't bad enough, the medical school was also uncomfortable with the sort of people Gevers was bringing from UCT, which had a much more liberal tradition. Among them, Gevers recalls, was a young Jewish student who had been involved in black African trade unionism, and who wore sandals and grew his hair long. Could he not be removed, the registrar pleaded with Gevers?

Gevers stuck to his guns. He also did not move his family to the northern suburbs, but stayed put in Rosebank, the leafy suburb below UCT where his artist wife had been born. There, they bought an old house that became their long-term home. Gevers says that he has done some of his best thinking and writing, as well as singing and piano-playing, in his home office overlooking a lush garden with its exotic Kiri tree, imported from the Far East and planted by him only a short time after the Gevers moved in.

At Stellenbosch he changed his field of study to cardiology and how the heart muscle works. By now, he was confident in his ability to switch between study areas – his many earlier career changes had ensured this to be the case. He loved the challenge of setting up the new department, the freedom to hire people and set up new policies and ways of working. He also enjoyed the teaching, which he had discovered a knack for, to his own surprise, during his time overseas. Gevers took on an extra teaching workload to allow the junior scientists more time to do research, and his enthusiasm and skill made him a popular lecturer at the medical school.

The mid-70s is also when Gevers, as he likes to put it, discovered his skill for 'getting things done'. In 1974, he created and became the founding President of the South African Biochemical Society. He lobbied for and succeeded in getting South Africa admitted to the International Union of Biochemistry, despite the academic sanctions against his country at the time.

TRANSFORMING SA's ACADEMY

In 1978, however, his *alma mater* offered him a job he could not refuse. He returned to UCT to mimic what he had done at Stellenbosch – setting up a research and teaching department in medical biochemistry, including new MRC units on muscle research and atherosclerosis. He hired a mix of science and medical graduates to populate his centre, having realised the value of having both sets of expertise at hand. He began studying why some people in South Africa suffer from early-onset and life-threatening

heart attacks, including the genetic factors that make people susceptible to the condition. This work led to the development of diagnostic tests that can help doctors identify patients at risk.

Gevers stayed at UCT until his retirement in 2002. From 1990 to 1991, he was Acting Deputy Vice-Chancellor, a role he then took up full time until his retirement. From 1996, he worked as senior DVC with Dr Mamphela Ramphale, UCT's first black Vice-Chancellor.

As South Africa made the transition to democracy, Gevers played a central role in revitalising its academic community. In the late 1980s, he had already begun the transformation of the Royal Society of South Africa (RSSAf). In the mid-90s, Gevers was one of the senior academics involved in drafting a vision for a new, inclusive academy to become an alternative to the old RSSAf and the Afrikaans-speaking academic community's *Suid-Afrikaanse Akademie vir Wetenskap en Kuns*.

The new Academy of Science of South Africa (ASSAf) was launched with 100 inaugural members in 1996 – a feat that owed much to Gevers' tireless mediating between the English and Afrikaans academics on the one hand, and with the country's new political leadership on the other. He served as ASSAf's President from 1998 until 2004, and played a leading role in producing its first two influential reports, one on scholarly publishing in South Africa, the other on HIV/Aids, TB and Nutrition.

Gevers remains passionate about South African science. His best advice to young people who want to excel? "Capitalise on your assets. Don't be scared to aim high. Above all, be creative and innovative." His own path wasn't always smooth, he says, and perhaps staying in America would have been more straightforward than returning to South Africa. But, it would probably have been boring, he says with a smile. "This has been far more fulfilling as a life."

| DAVID GLASSER |

TOP THREE AWARDS

- Honorary Doctorate from Wits, 2012
- NSTF-Billiton Lifetime Achievement Awards, 2011/2012
- Harry Oppenheimer Memorial Fellowship and Gold Medal, 2001

DEFINING MOMENT

There is no single one. I feel that defining moments are when I get what turn out to be good ideas.

WHAT PEOPLE DO NOT KNOW

I am not telling!!!



WORKING TOWARDS ECONOMIC BENEFIT

On 29 September 1936, David Glasser was born in Alexandria in the Eastern Cape. A strong scholar, he was placed in St Andrews School in Bloemfontein for his primary education, going on to complete his secondary schooling at Grey High School in Port Elizabeth. Matriculating first class in 1954, Glasser was placed fifth in the overall aggregates in the province. Always possessed of a keen curiosity about how things work, science seemed to be the logical career choice. Glasser elected to follow his brother into the field of chemical engineering, obtaining his BSc in chemical engineering with second class honours from the University of Cape Town (UCT) in 1958. Discussing his career choice, Glasser maintains that there is a genetic component, joking that his family, on his own side as well as by marriage, is overrun with chemical engineers. Glasser then moved to the United Kingdom, where he attended the Imperial College of Science, Technology and Medicine in London. He was awarded the PhD DIC in 1964, with his thesis titled *Some Kinetic Problems in Oxidation Chain Reactions*.

Upon his return to South Africa, Glasser was appointed lecturer by the University of the Witwatersrand's (Wits) Department of Chemical Engineering. In this department, he played an important role in modernising the chemical engineering programme, introducing optimisation and mathematical modelling into the course as well as through his innovative teaching of thermodynamics. He was a key player in the amalgamation of the respective departments of Chemical Engineering and Metallurgy, which joined to become the School of Chemical and Metallurgical Engineering. In addition to his work as a lecturer, he also was responsible for the development and presentation of diverse accredited industry-based short courses.

In 1971, Glasser attained the rank of Professor, serving as Head of Department of Chemical Engineering from 1979 until 1983, and again in 1991 until 1993. He was Dean of the Faculty of Engineering from 1986 to 1989 as well as being elected a Senate Member on Council in 1987. His period as Dean coincided with a period of political transition in South Africa, and Glasser was pivotal in developing promising young students from previously disadvantaged backgrounds, aiming to increase numbers and success rates.

An important element of his developmental initiatives was taking over the Anglo-American cadet scheme, comprising a year-long programme for young black engineering students before university which prepared them to excel in their studies. He has been a prolific mentor of postgraduate students, and to date, has supervised or co-supervised over 58 MSc students to completion, as well as 52 PhD students. Many of these students have gone on to become highly successful academics placed in internationally renowned tertiary institutions.

Glasser's research has covered a range of topics, including kinetics, thermodynamics, modelling and optimisation, focusing on aspects such as the use of temperature to measure chemical kinetics, the development of homotopy, variational and optimisation issues, and spontaneous combustion modelling in coal mines.

In his early work as a researcher, Glasser worked as a consultant on a number of coal mines, investigating the issue of spontaneous combustion of coal and coal wastes in mines. This spontaneous combustion of coal has numerous negative effects, not only because it represents profits lost by the mines, but also because of the ensuing air and water pollution. Glasser's studies in this area included the development of simple tests to assess materials for their potential combustion, as well as large-scale studies that were used to inform the design and management of full-scale coal dumps. As a consultant to the Grootgeluk Coal Mine in Limpopo and the Leigh Creek Mine in South Australia, he worked to improve the functioning of these mines, suggesting procedural improvements that could reduce the risks of spontaneous combustion taking place, as well as setting measures in place to manage such hazards should they occur. The processes utilised by many coal mines today, in South Africa as well as internationally, are based on Glasser's work.

In addition to this, he also worked on the modelling of fires in tunnels, another potential hazard in the mining industry. This work aimed at clarifying the processes occurring during fires in ventilated ducts, to understanding the interaction between the flow, reaction and transport processes, thereby contributing to improved safety conditions in underground mines.

HIGH-PROFILE RESEARCH

Together with Diane Hildebrandt, one of his former PhD students, Glasser has been involved in numerous high-profile research projects, initially under the auspices of the Centre of Materials and Process Synthesis (COMPS) at Wits, now based at the University of South Africa and renamed the Material and Process Synthesis Research Unit (MaPS). This initiative combines cutting-edge research with industry needs, with a number of patents being registered as a result of activities undertaken in this regard and also supplying technology to commercial plants.

The development of the Attainable Region (AR) method is one of these achievements. This groundbreaking method was developed with a view to optimising chemical reactors. It has been successfully applied in biomedical research such as interpreting imaging experiments, heparin removal in blood and in the development of an artificial liver. The research has since been extended to include other processes, namely mass and heat transfer and separation. In so doing, this research has formed the groundwork of new, optimised methods of process synthesis, eliminating much of the guesswork that was previously involved. The work they have produced in this regard is now internationally recognised and is included in numerous textbooks and syllabi (both at undergraduate and postgraduate level) relating to the design of chemical reactors. A textbook on the topic published by Wiley USA is due to appear in 2016.

The development of the Column Profile Map (CPM) method for distillation design is another piece of influential research that Glasser's team has undertaken. This finding has been described as "one of the three most important developments in distillation over the last decade", as it enables the synthesis of intricate distillation columns and systems in order to accomplish defined separations. This has also allowed for an enhanced understanding of reactor engineering and separation in a unified theory, rather than being seen as two disparate fields as has been the case. This shift in perspective can allow researchers to further synthesise and optimise a wide range of operations in chemical engineering, applying these techniques in order to better predict the optimal conditions for complex multifunctional processes, such as reactive distillation.

Process synthesis forms another important aspect of the research which the team has engaged in. "We have shown that chemical plants can be viewed as heat engines in which the heat can be used to put in the work that is needed to make the plant feasible," explains Glasser. This process uses fundamental thermodynamics and allows researchers to set a number of targets for plants functioning at their optimal state, using raw materials efficiently and with minimal carbon dioxide emissions. Then, using a flow-sheet system, researchers are able to evaluate actual performance against these initial targets. One related aspect which has formed a branch of concurrent research, is the kinetics of the Fischer-Tropsch reaction used in the oil-from-coal process.

The contributions which have been made by Glasser and his associates have been significant to the field of chemical engineering, with potential applications in a variety of areas touched by the chemical industry, which is responsible for the manufacturing of essential products such as plastics, petrol, paper, paints, synthetic fibres, and fertilisers. The impact of this work could be viewed as an economic benefit for the manufacturers themselves, allowing savings on cost. Moreover, their findings could be applied in order to use natural resources more efficiently, resulting in less waste, and generating less pollution – making the industry significantly more environmentally-friendly. Current plants may be able to decrease carbon dioxide emissions, while the employment of these ideas in the design of new plants can assist in minimising emissions in future.

An acknowledged world leader in his chosen field, Glasser has published more than 170 articles in peer-reviewed journals, as well as having co-authored numerous books and book chapters. He has frequently been invited to present at international conferences, including the Dutch Chemical Engineering Congress, World Coal-To-Oil Conference, the Foundations of Computer-Aided Process Design (FOCAPD) and the Process Development Symposium. In addition to this, he has served as Associate Editor of the *Chemical Engineering Journal*, as Editor of the Kluwer international book series on chemical engineering and as a reviewer for a number of international publications.

Glasser has been involved in the South African Institute of Chemical Engineering in a variety of roles, serving on the council, as well as in the capacity of president. He has also served on the Professional Advisory Committee of the Engineering Council of South Africa. He is a Fellow of both the South African Institute of Chemical Engineering and the Royal Society of South Africa and is an elected member of the South African Academy of Engineering, the American Institution of Chemical Engineering and the Academy of Science of South Africa (ASSAf). He has had the highest rating possible, the A1-rating, conferred upon him by the National Research Foundation. He first received this rating in 1998, subsequently renewed in 2005 and 2011.

Over the span of his career, he has acted as Visiting Professor at a number of esteemed institutions, including City College in New York, the University of Houston in Texas, Tel Aviv University in Israel, McMaster University in Canada, the Australian-based Universities of Sydney and New South Wales, as well as Princeton University, USA, where he was a Fulbright Scholar.

The recipient of plentiful awards, both in his personal capacity as well as in his role as a member of his research team, it is clear that Glasser is an outstanding researcher who has earned the respect of his peers.

FAMILY MAN

His family is an essential part of his life, and he relishes time spent with his children, Nadine (senior lecturer in computer science University of New South Wales) and Benjamin John (professor of chemical engineering Rutgers University USA), as well as with his grandchildren.

He has been married to his wife, Sylvia, for over 50 years. Sylvia 'Magogo' Glasser is a legend in her own right in the field of dance. She made a name for herself as an innovative choreographer, blending a number of eclectic styles and integrating elements of her training as a social anthropologist. She established her own multiracial dance company in 1978 at the height of apartheid. Actively training young dancers from all backgrounds, the rehearsals of Moving into Dance Mophatong were originally held in the Glassers' garage at their home in Victory Park. She has been made a Knight of the Order of Orange-Nassau by the Netherlands and given the Order of Ikhamanga (Silver) for her forward-thinking work in this capacity. The company maintains its reputation as an inventive contributor to the South African arts, and until recently both Sylvia and David Glasser remained active in the management of this organisation.

He is a keen sportsman, enjoying swimming in the sea as well as bodysurfing, and notes that he has played squash (half Blue Imperial College) and tennis (Blue Imperial College) fairly competitively in the past. He also was fond of playing bridge, but gave it up as it became too time-consuming. In addition to these activities, he enjoys reading.

Although he officially retired in 2004, he has been rehired on contracts and continues to be an active researcher and supervisor. While the awards are evidence of his contributions, Glasser says that his deepest satisfaction in his career has come from his collaboration with colleagues, suddenly realising that they've solved a problem that they've been working on for some time. Working in teams is a fulfilling aspect of his work as a researcher, and he continues to be motivated by the development of young and enthusiastic students and colleagues.

| GLENDA ELISABETH GRAY |

TOP THREE AWARDS

- Nelson Mandela Health and Human Rights Award, 2002
- National Order of Mapungubwe (Silver), 2013
- European and Developing Countries Clinical Trials Partnership (EDTCP) Outstanding African Scientist Award, 2013

DEFINING MOMENT

Realising that mothers had the questions to guide her research work.

WHAT PEOPLE DO NOT KNOW

While she's seen as an extrovert, she is, in fact, shy – a “socio-phobe” happiest at home with her family with a little, rarely secured, time to think.



GUIDED BY THE NEEDS

The road to Kliptown runs more-or-less directly south-west from the centre of Johannesburg, past the core of Soweto, and then takes a sharp turn to the right through Eldorado Park towards the bleak Walter Sisulu Memorial Square. Here, the Kliptown Perinatal HIV Research Unit (PHRU) is located, where one of Gray's many offices is to be found. Up the stairs and into a grey concrete corridor, five other organisations along, the clinic door opens into a glass and pressed-wood partitioned area. And in one of these areas, set up with the means for making tea, coffee and lunch, Professor Glenda Gray sits at a table trying to come to terms with the recent re-configuration of her laptop.

The fifth of six children, born in Boksburg on the East Rand (her mother washed the kitchen floor before Gray's birth at home and, afterwards, made tea for the midwife), Gray grew up as the strong-minded, strong-willed daughter of a strong mother. And partly for this reason, Gray's career as physician, researcher, manager, leader and highly respected, international award winner, has taken a less direct route.

Her early career did, though, follow a more-or-less direct course. Gray completed an MBChB degree at the University of the Witwatersrand (Wits) in 1986. She describes her years at Wits Medical School as a golden age, when the professors who taught her and her fellow students included internationally renowned scientists, including anatomist and palaeontologist Philip Tobias, and organ transplant pioneer, Bert Myburgh. These "princes of medical research" were not just great scientists, she says, but also wise and witty teachers – a good start to any young person's career.

Seven years later, she was admitted as a Fellow in Paediatrics of the South African College of Physicians. During the intervening years, Gray's primary career moved steadily through the stages normally associated with those of a medical practitioner in the public service and academia. She served her medical internship at the Coronation Hospital in Johannesburg in 1987, and then immediately became the Senior Medical Officer for Paediatrics at Coronation in 1988 before moving to the Chris Hani Baragwanath Hos-

pital, in the middle of that year, as the Medical Officer in Intensive Care. Between 1988 and 1995, Gray moved between positions at Wits and Baragwanath – but in 1996, that reasonably traditional road reached a fork and, in the words attributed to Yogi Berra, having reached the fork, she took it, founding (with James McIntyre) the Perinatal HIV Research Unit based at Wits.

While remaining, for a while, a medical practitioner and an academic at Wits, Gray became the manager and leader of the PHRU as its Executive Director, and a medical researcher. The shift was not easy. Working with patients at Baragwanath, facing the reality of mother-to-child-transmission of HIV, she realised that she had to do whatever possible to find a solution to the challenge. Her fear was that she wasn't smart enough to be a medical researcher – but she talked to the mothers and, listening to them, realised that "they were the clever ones – they had the questions" and it was those questions, which at the time were questions without answers, which led to the new route in her life, and guided her research. This was probably the most defining moment in Gray's life.

ANYONE CAN BE A SCIENTIST

Gray also found it difficult to relinquish her practitioner's role which she soon had to do. "I loved being a doctor, and moving from the

immediate reward of working with individual mothers and babies, to the 'detached' work of the laboratory – with long term, although much greater impact" – was not without its costs. In the process, she experienced the sense of being a paediatrician being pushed into a researcher's role. She soon came to believe, however, that "anyone can be a scientist: all you need is curiosity and persistence".

What Gray leaves out of this notion, however, is the additional need to be highly intelligent and energetic and, in this arena of research, deeply caring and committed to human well-being – four qualities in which she abounds.

It did not take long for these two more-or-less parallel roads to become an extensive network of careers and commitments. The territory through which these routes made their way consisted largely of barren lands, dominated by the unknown, although dotted with points of knowledge and experience. Through her own research, and active memberships of numerous research groups, she began to help turn the points of what was known into regions that slowly spread their way into the barren areas of what was not known.

In 2013, while still working for the PHRU, Gray became the Director of the Office of AIDS Research at the South African Medical Research Council (MRC) and, just one year later, the President of the MRC – a demanding and high-profile position which she still holds. The time in between was not without additional learning and opportunities to advance her research base and credentials. In 1999, she participated in an intensive summer programme in clinical epidemiology at Cornell and on the basis of an International Fogarty Award, spent time as a postdoctoral fellow at Columbia. In 2011, the National Research Foundation (NRF) awarded her the status of an A-rated scientist, by which time she had been elected a Member of the Academy of Science of South Africa (ASSAf) and, for four years, has been the Chair of the ASSAf Standing Committee on Health – and has served on two of ASSAf's expert panels. Her engagement with research and research teams goes considerably further as part of her role in filling in those 'barren areas'.

As far as clinical research is concerned, Gray heads the National Institutes of Health funded Soweto Clinical Trials Unit, with three clinical research units, which undertake protocol specific work for the HIV Prevention Trials Network (HPTN). She was responsible for overseeing the first HIV vaccine trials that were run in South Africa, and has also spearheaded the clinical development of the South African AIDS Vaccine Initiative's HIV vaccines. She was the protocol chair for the HIV Trials Network (HVTN) and is the protocol chair for the HVTN 073 trial that is investigating South Africa's two HIV vaccines, the SAAVI DNA-C2 and the SAAVI MVA-C as well as the Protocol Chair of HVTN 097, evaluating the immunogenicity of the RV144/Thai study in South Africa, which has an annual budget of R300 million a year. Gray is also responsible for the Product Development Pathway for the HIV Vaccine Licensure Track. The P5 programme will lead to the expansion of clinical trial infrastructure in Southern Africa. This programme has a budget of R2,5 billion. Gray is a member of the AIDS Vaccine Advisory Committee for WHO/UNAIDS, the Scientific Advisory Committee for the International AIDS Vaccine Initiative, and the Scientific Advisory Board of the Centre for HIV/AIDS Vaccine Immunology and Immunogen Discovery (CHAVI-ID) with Scripps. She says that she engages in the research that "keeps her enchanted".

In her capacity as Chair of the ASSAf Standing Committee on Health, she was invited to represent the Academy in the National Health Research Committee and provided technical advice to the Director-General of Health on research and development related issues.

In 2002, together with James McIntyre, she was awarded the Nelson Mandela Health and Human Rights Award for pioneering work in the field of Mother-to-Child Transmission of HIV-1 – the award which means the most to her – not just because of the award coming from Mandela, but because it most closely captures her most important concerns in life – health and human well-being and rights.

Gray's research has resulted in the publication of over 250 internationally recognised papers and she has given a vast number of public addresses related to her research. It is not surprising, then, to know that she is a Mem-

ber or Fellow of eight local and international professional and scholarly associations, and that she serves on several panels and committees ranging from vaccines, to global health to assessing priority setting for health in developing countries.

As for the future, Gray hopes that as she enters her third year as the President and CEO of the MRC, her leadership will have been consolidated and her teams will be working in coordinated ways on their projects. If this turns out to be the case, she will continue her research work and – importantly – devote more of her time to her professorial work at Wits.

Is there a way to summarise Gray's illustrious and hard-working, diverse career?

Probably not. But at the very least, mother-to-child-transmission of HIV, and research and testing around vaccines would probably take centre stage. These are the themes that run along the roads of her career, and fill the landscapes surrounding the roads. Any summary would be incomplete, however, if one were not to include her fundamental humanism, her concern and care for women, children and families affected by HIV and AIDS – and her determined, steadfast efforts to address the problems that the disease hauls along in its wake.



| WINSTON HIDE |

TOP THREE AWARDS

- Harry Oppenheimer Memorial Trust Fellowship Award
- National Research Foundation President's Award
- Associate Professorship at Harvard

WHAT PEOPLE DO NOT KNOW

My years at the University of the Western Cape were not without real challenges, and they demanded of me considerable reliance on my ethical principles. I am, a spiritually-orientated person, just as happy reflecting on my place in nature, as I am writing a scientific paper; and blessed with an ability to see, appreciate and help to develop the potential in others.



LIVING AND SHARING A LIFE OF SCIENCE

Winston Hide is a peripatetic entrepreneur – an entrepreneur who aims not to make financial profits, but to create groups and networks of researchers, the profits of which are more and better science and also support for, and the development of, younger scientists. Peripatetic, because from his youngest days he has been on the move¹ – from Pretoria, where he was born, to Cologne, London, back to Pretoria, then to Johannesburg, London (to school) and Cardiff (to university), while, as postgraduate student, postdoctoral fellow and Professor, Hide has moved from Wales, to Temple University in Philadelphia, Baylor College of Medicine, the University of Texas in Houston, the Smithsonian Museum of Natural History in Washington DC, Houston (again), San Francisco, the University of the Western Cape, Cambridge Massachusetts, and the University of Sheffield.

These travelling years do not, however, imply an absence of serious research, scholarship, and publications – and postgraduate student supervision. Quite the contrary. Since his own postgraduate work, Hide's association with a wide range of institutions has been in support of what has become a highly respected life as a researcher, teacher and manager of scientific ventures of many kinds.

Initially, the prognosis was not particularly encouraging. Asked how he came to enroll as an undergraduate student in the University of Wales, he explains: "I failed my school-leaving exams and had to find a backdoor into a university. I wasn't a very mature schoolboy." His experiences subsequently changed unexpectedly, however – several times. An initial shift was the result of his having developed a passion for Zoology (he had read Gerald Durrell's early novels as a young boy) and so he successfully majored in order to make a career in the discipline, hoping to work, eventually, in a museum such as the Smithsonian Museum of Natural History. After considerably greater achievements as an undergraduate than as a schoolboy, Hide's next unexpected change came as a result of his father persuading him that museum curatorships were unlikely to offer many op-

¹ Winston's father, Cyril Hide was a Science Counsellor in the South African Diplomatic Service as part of the CSIR.

portunities as far as careers go, and that he should, instead, study molecular biology, which he did.

The next change was more by way of an extension to molecular biology than a change in direction. By this time, as a Masters student at Temple University, Winston had a personal computer of his own and, to his delight, discovered that he could use his PC not only to record the sequence of DNA, but also interpret it. He was 'gripped,' and it was this development in his student years that convinced him that, with his profound interest in evolution, molecular evolution was the route he would follow. "I knew that I would always work 'in silico' [rather than 'in situ'] once I realised that I could analyse DNA sequences and use them to define the relationships between species." So began his career in bioinformatics.

Working on a PhD towards the end of the 1980s the next – and this time, expected – step. He didn't particularly enjoy his PhD topic, but as a postgraduate student, he was given opportunities to attend two high-level workshops on molecular evolution. These provided him with almost unique opportunities to extend his knowledge and enthusiasm – not least as one of the people he encountered in Los Angeles was Linus Pauling, who encouraged him always to think about the meaning of the research he was doing and about how he would go about publishing his findings.

Hide's three terms as a postdoctoral fellow started with a period working with Professor Wen Hsiung-Li at the University of Texas in Houston, and it was during this time that he co-published his first paper in *Nature* – entitled "Is the guinea pig a rodent?" Hide points out that "we were wrong about the guinea pig" but the methodology used represented a major breakthrough in the use of molecular data for understanding evolution and the paper generated a considerable trail of commentaries and responses. In recognition of its methodology, the paper was also listed as one of the top 50 scientific discoveries of the year, while the results were reported in the *New York Times*, the *Times* of London, *Figaro*, *The Economist*, the *Philadelphia Enquirer*, the BBC and National Public Radio (in the USA).

A second term of postdoctoral fellowship followed at the Smithsonian Museum of Natural History with Dr David Pawson – and a third (back in Houston) at the Baylor Human Genome Centre, working with Australian Geneticist Dr Richard Gibbs. These periods of postdoctoral fellowships were followed in 1994 and 1995 by spells in the commercial world of genomics, first as Director of Genomics at the MasPar Computer Corporation in Silicon Valley and then as a Consultant Systems Architect in Genome Bioinformatics at the RW Johnson Pharmaceutical Research Institute in San Diego.

RETURNING HOME

By this time, Hide was ready, in terms of both his range of research experience and his political ethics, to return home, to his country of birth, which he did in 1996 to a newly minted South African democracy. He accepted an Associate Professorship at the University of the Western Cape with the challenge of founding the South African Bioinformatics Institute (SANBI). Initial funding for SANBI came from the Foundation for Research Development – now the NRF – “Going home, and being accepted, was one of the most important steps in my life,” says Hide. Within four years, SANBI had graduated the first PhD in bioinformatics in Africa, and had held the first South African workshop on genomics, organised with Professor Sydney Brenner, Nobel Laureate. Hide also managed to help raise funds for a New Life Sciences Building at the University of the Western Cape – to house SANBI and other research entities.

Two years after founding SANBI, Hide was appointed to a Full Professorship (1998) and during his 12 years at the University of the Western Cape he was the Founder (or Co-Founder) of three further Units – the WHO African Regional Training Centre for Bioinformatics in 2003, the MRC Unit for Bioinformatics Capacity Development in 2000 and the South African National Bioinformatics Network (2003).

Hide, scientific entrepreneur, was also the Director of the European Molecular Biology Network Node for South Africa (from 1997) and the Director of Bioinformatics for the National Institutes of Health-funded AIDS Research Programme in CAPRISA. In 2003, he became the bioinformatics and ge-

nomics advisor to the WHO Tropical Disease Research Programme and also the Director of Bioinformatics for the South African AIDS Vaccine Initiative. In 2004, he was appointed as a Kerr Research Fellow in the Ludwig Institute for Cancer Research and in 2005, Director of the USA National Institutes of Health-funded Fogarty International Graduate Training Programme in Biomedical Informatics.

At this stage in his working life, Hide was open to the possibility of a period of sabbatical leave, and was attracted to the opportunity of a period as a Visiting Professor at Harvard's School of Public Health in 2007. In order to support his time away, Hide applied for an Oppenheimer Memorial Trust Fellowship Award. He was shortlisted, interviewed (“the most difficult interview of my life – I thought I'd never get it”), received the award, and was able to accept the visiting position in 2007. By 2008, he was appointed to an Associate Professorship in Biostatistics in the school.

CAMBRIDGE MASSACHUSETTS YEARS

So began the substantive “Cambridge, Massachusetts” years of his scientific life – a phase that continues today. It is, unsurprisingly, a phase that started not just with an Associate Professorship but with a founding: in this instance, the establishment of the Harvard School of Public Health's Bioinformatics Core, in 2008, of which he became the Scientific Director – always the scientific entrepreneur and generator of opportunities for others. “I seek to apply the development of people, tools and systems for delivering translation from biomedical knowledge into therapeutics,” – clarifying in just two lines the driving talent that is a critical feature of his working life. In that same year, he became an executive on the Programme for Quantitative Genomics (2010). A year later, Hide founded (and became the Director of) the Centre for Stem Cell Bioinformatics in Harvard's Stem Cell Institute. While fulfilling these responsibilities, he also became a Visiting Scientist (2013 – 2015) in the Translational Bioinformatics Programme at Biogen Inc, a multinational biotechnology company based in Massachusetts, which specialises in the discovery, development, and delivery of therapies for the treatment of neurodegenerative, hematologic, and autoimmune diseases for patients around the world. Hide also found time to assume

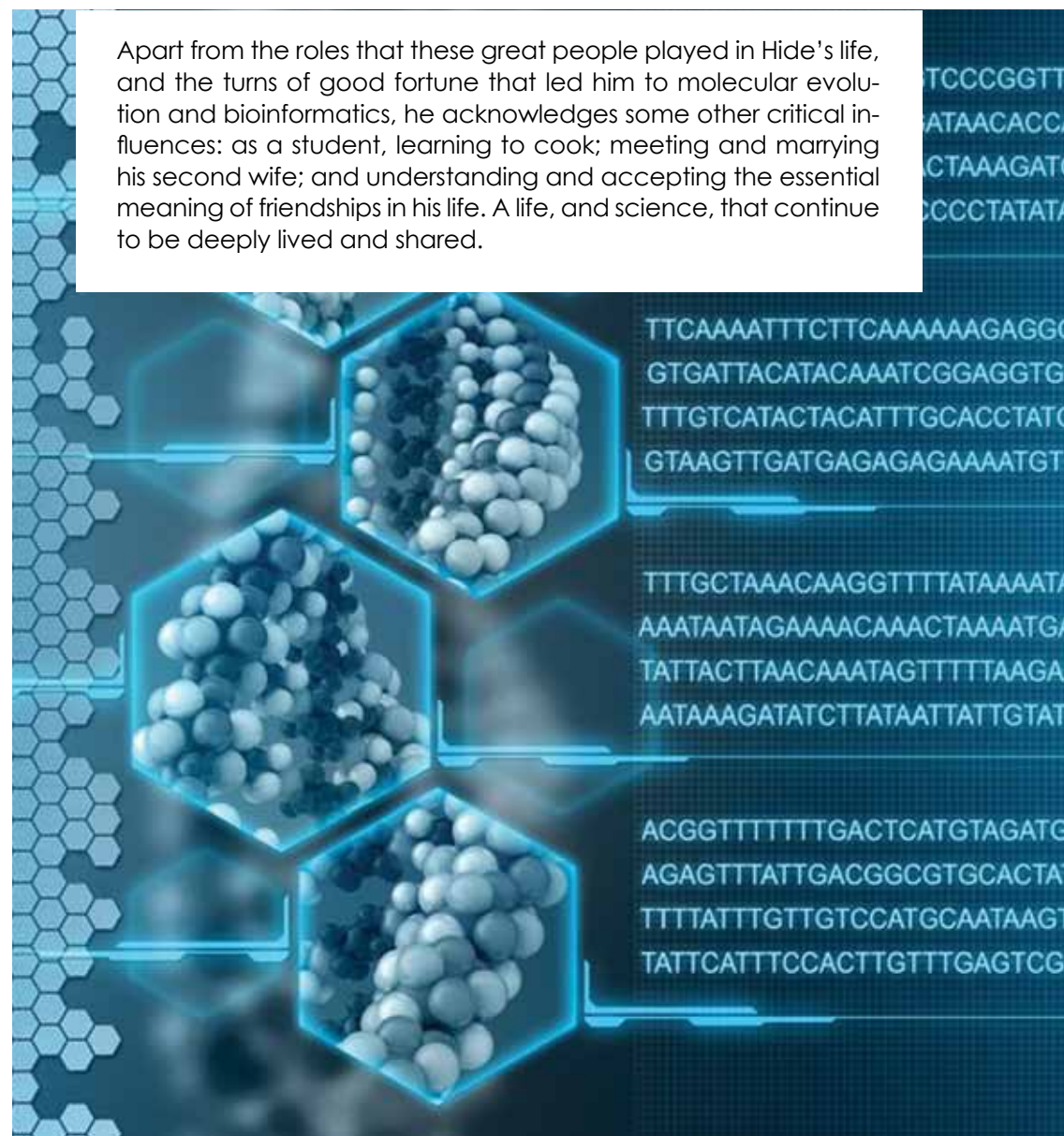
responsibilities as the Director of Bioinformatics for the Alzheimer's Genome Project supported by the Cure Alzheimer's Foundation – consistently delivering translation from biomedical knowledge into therapeutics.

In 2014, the Cambridge work still in full swing, Hide accepted a Chair in the University of Sheffield (in South Yorkshire) – beginning what might be called the ongoing “transatlantic” years of his career – ever peripatetic and still entrepreneurial. The Chair is that of Professor of Computational Biology, at the Sheffield Institute for Translational Neurosciences within the Department of Neuroscience of the University and coincided with his founding of the Centre for Genome Translation in the Institute, which he also directs. In his post at Sheffield, Hide has become the Academic Director of Connected Health Cities in Yorkshire and has recently also taken up a Visiting Professorship at MIT's Computer Science and Artificial Intelligence Laboratory.

Two critical riders consistently accompany Hide's accounts of the research entities and networks whose creation he has led (and often directed), and the students and young researchers he has encouraged and helped to develop. The first is the considerable credit that is due, and a valued debt owed, to colleagues with whom he worked in realising his many achievements. “So many were joint ventures,” he points out, “with people whose potential was clear to me.”

The second is to acknowledge four great leaders and scientists who have, in their turn, mentored and guided him. Prof Brian O'Connell (then Vice-Chancellor of the University of the Western Cape) was, Hide says, a wise and considerate mentor who provided him with constant support. Prof Russ Altman, Chair of the Department of Biomedical Engineering at Stanford showed Hide how to find and then nurture the potential in others. Prof Sydney Brenner encouraged Winston Hide to “go home” where he found himself accepted and so flourished; and Prof Salim Abdool Karim whose skills as a researcher and manager taught him the abilities he needed to manage diverse and sometimes quite difficult groups of colleagues. Each of the four changed his life in positive ways and laid the basis for his success as a leader in his field.

Apart from the roles that these great people played in Hide's life, and the turns of good fortune that led him to molecular evolution and bioinformatics, he acknowledges some other critical influences: as a student, learning to cook; meeting and marrying his second wife; and understanding and accepting the essential meaning of friendships in his life. A life, and science, that continue to be deeply lived and shared.



| DIANE HILDEBRANDT |

TOP THREE AWARDS

- The African Union Scientific Award, 2009
- Distinguished Woman Scientist Award, South Africa, 2009
- ASSAf Science-for-Society Gold Medal Award, 2010

DEFINING MOMENT

I think life is made up of many moments that are important and that motivate and inspire. These include making a discovery in your research – it is awesome being the first one to see how wonderfully some (very tiny) aspect of the universe is put together; working with young people and seeing them develop into world-class researchers and being able to do things that could improve the quality of life of the poorest in Africa and the world.

WHAT PEOPLE DO NOT KNOW

My aim in life is to be bored – then I will have done all the things I want to do.



RESEARCH FOR IMPROVING LIVES

Diane Hildebrandt was born in Chingola, Zambia and came to South Africa in 1968. Her childhood was spent mostly in Rustenburg, where she completed primary school at Fields Primary School. She undertook her high-school education at Grenville High, the only government high school for English-speakers in Rustenburg at the time. The core of her matric subjects were mathematics and science, with English, Afrikaans, biology and accountancy. From here, she went on to complete her undergraduate and postgraduate studies at the University of the Witwatersrand (Wits).

Hildebrandt says that her entry into the world of engineering was a fortunate accident. "I enjoyed science at school but never thought that girls could be engineers," she recalls, and indeed, there were very few women who were enrolled for this course of study at university level. She changed to chemical engineering at the end of her first year because she believed that there were more opportunities and better salaries for engineers. Although she still thinks this is generally true, she now freely admits that it is not necessarily the best basis for a career choice. "However," she continues, "in this rather random way I became a chemical engineer and I suppose that this is sometimes the way that important decisions are made – by luck and chance". Over the course of her career, she has been pivotal in undertaking research on chemical reactor optimisation, process synthesis, reactor and separation system synthesis, Fischer-Tropsch and biotechnology – specifically the use of biological processes for biogas production and water clean-up.

In 1981, she completed her BSc in chemical engineering with distinction. This was followed by the attainment of her MSc in 1983. Upon entering the workplace, she spent a number of years in the employ of the Chamber of Mines Research Organisation, where she worked as a professional assistant in the Environmental Engineering Laboratory. In 1984 she joined Sastech, SASOL as a process engineer. In 1985, she was appointed as senior lecturer in the Department of Metallurgy at the Potchefstroom University for Christian Higher Education, and at this time she also undertook her PhD studies at the University of Witwatersrand under the supervision of Professor

David Glasser, whom she credits as being one of the major influences on her career.

In 1988, she joined the faculty of Wits and in 1989 she was awarded her PhD. Her thesis was titled The Attainable Region Generated by Reaction and Mixing, in which she developed a new method for optimising chemical reactors – the Attainable Region (AR) method. She reflects, "I did a PhD simply because of the challenge – I wanted to see if I could do it". At the time, she made her choice of topic because she felt that it would be the easiest to work on – however, over the years, her contribution to this area has been consistent and far-reaching. Focusing on the optimisation of reactors, the work she undertook in her PhD studies has been included in several textbooks prescribed at undergraduate level, as well as being frequently cited in the field of chemical engineering.

In 1991, Hildebrandt had the opportunity to spend her sabbatical as an Assistant Professor at the prestigious Princeton University in the United States, returning to the University of the Wits at the end of that year. In 1998, Hildebrandt was promoted, taking up the post of the Unilever Professor of Chemical Engineering at the School of Process and Materials Engineering, a position that made her the first woman in South Africa to have been appointed as a full Professor in chemical engineering. This achievement was echoed in the Netherlands, when in 2003, she was appointed as a part-time Professor of process synthesis at the University of Twente, thus becoming the first woman professor of chemical technology in the Netherlands. She says jokingly, "I thought that it was great that a woman from Africa should go to Europe and lead the way!"

In 2005, the School of Chemical and Metallurgical Engineering established the Centre of Materials and Process Engineering (COMPS), a research centre where Hildebrandt functioned in the capacity of Professor and Director alongside her mentor, Professor David Glasser. Later, she also filled the additional role of the South African Research Chair of Sustainable Process Engineering. Here, she and Glasser developed numerous methods for the improved efficiency of equipment and chemical processes.

In 2013, Hildebrandt and the COMPS group moved to the University of South Africa forming the Material and Process Synthesis (MaPS) Research Unit. The formation of the unit positioned Unisa as a leader in developing Sustainable Energy Solutions for Africa and South Africa. The research of MaPS focuses on utilising underutilised resources, such as waste materials, to produce fuel and electricity. Hildebrandt is currently the Director of MaPS and is a Professor of Chemical Engineering at Unisa.

IMPROVING PROCESSES

Building on her work on chemical reactor optimisation, Hildebrandt has further explored comminution. This is a process fundamental to the mining industry, which is a major contributor to the South African economy. Comminution deals with the breaking down of mined rock into fine particles in order to extract minerals. Hildebrandt and Glasser applied the AR method to these processes, and were thus able to contribute to significant improvements in the extraction process, as well as increased energy efficiency associated with these procedures. This is an ongoing project, liaising with the mining industry to implement these findings in practice.

Another aspect of Hildebrandt's work has dealt with the optimisation of distillation systems. This is one of the most common methods of separating elements in the chemical industry, but traditionally these processes have used extreme amounts of energy. Hildebrandt and Glasser worked on designing distillation systems which would be more energy efficient, and so developed a distillation system design known as the Column Profile Map (CPM) method. This has been described as "one of the three most important developments in distillation over the last decade". In addition to its application in distillation, this method can also be applied to membrane separation.

Her team has also worked with a biomedical engineer in order to use imaging data obtained from patients to better analyse their state. She was also involved in the development of an efficient system for removing heparin from blood, and is now working on modelling the kidney and analysing the behaviour of neuromuscular blocking drugs.

While working at COMPS, her research group partnered with Golden Nest to develop a new, more efficient Fischer-Tropsch technology. Hildebrandt and Glasser have been working in this area for the last two decades. The Fischer-Tropsch reaction has great significance in the industrial arena, as it is used to produce synthetic fuels from coal, oil and organic wastes, but it is a very complex field of study which is still largely shrouded in mystery. Together, Glasser and Hildebrandt moved away from the traditional paradigm viewing it as a reaction alone, characterising it instead as a system with similarities to reactive distillation. Utilising the findings engendered through their research, they were able successfully to design and build a pilot plant for Golden Nest which could convert syngas into synfuel. This plant was built in Baoji, in the Shaanxi province of China. Hildebrandt headed up the team that was responsible for the conceptual design, overseeing the feasibility study, the engineering thereof, as well as the laboratory testing of the catalysts. This plant was later inspected by an international review committee, which approved the technology in use.

Their work extended to Chinchilla, Australia, when in 2005, Hildebrandt led a team contracted to LincEnergy to build a Fischer-Tropsch demonstration plant. The aim thereof was to test the concept of combining the Fischer-Tropsch process with underground gasification, a world first in this area. Her team conceptualised the reactor system, which has since been commissioned successfully, as well as overseeing the feasibility and engineering thereof.

Most recently, Hildebrandt and Glasser have been collaborating on improved process synthesis. This is a new way of designing flow-sheets for chemical plants, by making use of fundamental thermodynamics, in order to improve their use of raw materials while reducing carbon dioxide emissions, inter alia. Their work in these areas is currently being expanded as a biotechnology study. Small-scale modular units are under investigation, where organic materials (such as agricultural, municipal waste and medical wastes) can be utilised to supply fuel and electricity. Part of this investigates the installation of algal ponds on the outskirts of the plant, where local algae may be introduced to minimise the carbon emissions from the plant. Another branch of this research has investigated the reduction

of water tainted as a result of by-products from the Fischer-Tropsch process. In practice, these findings may contribute to improved design of artificial wetlands, as well as contributing to the clean-up of water contaminated with metals (such as acid mine water drainage) and biological materials.

Hildebrandt is particularly interested in how she can apply the results of her research to improving the lives of those who do not have access to energy and clean water. Governments are being challenged to provide infrastructure capable of servicing the increasing demands for energy, while simultaneously reducing the impact on the environment, particularly in light of the prohibitive costs involved. Also, chemical industries and power stations make use of carbon-emitting fossil fuels in their procedures, further contributing to global warming. Inefficient processes in place at these institutions lead to greater carbon emissions than would have been the case had they been better designed and operated. Optimisation of these processes looks at reducing waste, concurrently improving bottom-line performance, and where possible, converting these carbon containing waste products to fuel and electricity. The implementation of such processes can improve the situation, particularly in developing countries, on three fronts: supplying energy, creating jobs and cleaning up the environment.

She explains her contribution, saying, "The effects of global warming will put severe pressure on communities... Some of the forecasts suggest that these pressures will lead to revolutions and war – not an in-

heritance that we wish to leave to our children. It is essential that we solve this problem quickly while meeting the energy needs of society". Her research, encompassing all the key elements needed to make waste-to-energy technology work, has been instrumental in developing methods by which organisations may reduce their environmental impact, in turn contributing to greater security in meeting Africa's energy, fuel and food requirements.

Alongside her prolific research, Hildebrandt has been an active mentor to numerous students who have worked with her, living out her belief that each one is a person who can go out into the working world, potentially drive industry and make a contribution to the betterment of Africa. She has supervised and co-supervised approximately 50 PhD students to completion, as well as over 40 MSc students and a number of students from abroad – with several more currently in the pipeline. "You get to a stage where the 'learner' becomes the teacher," she says, "and the student now is far ahead of you in terms of their understanding and in generating new ideas. I love this moment because then I know that I have been successful... It might not be good for my ego, but it does mean I have done my job well, and it really is special".

| JAN-HENDRIK HOFMEYR |

TOP THREE AWARDS

- Harry Oppenheimer Fellowship Award and Gold Medal, 2002
- Beckman-Coulter Gold Medal of the South African Society for Biochemistry and Molecular Biology, 2003
- Havenga Prize for Biological Sciences from the *Suid-Afrikaanse Akademie vir Wetenskap en Kuns*, 2009

DEFINING MOMENT

“All my defining moments were linked to books.” He reveres the authors who have influenced him and is very deliberate in pointing out which thoughts belong to others in his field, which thoughts are his, and how his thoughts have been shaped by the works of others.

WHAT PEOPLE DO NOT KNOW

Hofmeyr is a musician, cabaret artist and actor, and he helped launch *Afrikaans Kabaret* in the 1970s and 80s in South Africa. “Music and theatre keep me sane. But I don’t have time to practise the flute and guitar every day. And if you can’t practise every day, your technique goes to the dogs.”



PERSPECTIVES ARE TO BE SHIFTED

In academia, change often happens slowly. Academics are born into a paradigm and, more often than not, they maintain that paradigm rather than interrogating and critiquing it. It is rare to find a researcher who is willing, much less eager, to look outside of his or her field and recognise when a paradigm can be improved upon or discarded entirely. Such an academic is Jannie Hofmeyr, Distinguished Professor at Stellenbosch University (SU).

Hofmeyr is unique in his constantly shifting perspective on his field and on science in general. He has moved from experimental to theoretical, from parts to the whole, from a dedicated discipline to interdisciplinarity. "What I like is to start something," he said, "to be out there where the buses don't run in the first place. That for me is fun. Then I start something and see if I can build it up and then I try something else. I've made big jumps in my life."

Perhaps his willingness to embrace change was instilled in him from a young age. Hofmeyr was born in Durban and lived in Pietermaritzburg until his father became the immigration attaché in Holland. Hofmeyr then lived in Holland until he was seven before coming back to South Africa where his family settled in Johannesburg. After matriculating and spending a year in the navy, Hofmeyr moved to Stellenbosch. From his well-travelled childhood, it may surprise some that he stayed at SU and has been there for 41 years. While it is common, even advised, for young academics to split their training among several institutions, Hofmeyr has never regretted staying put. "Stellenbosch is such a fantastic place. You get to go everywhere in the world anyway for research and conferences, so I've never regretted staying."

Hofmeyr began his academic career during his Honours year. After obtaining his BSc biochemistry/microbiology (*cum laude*) from Stellenbosch in 1974, he started his Honours and began working in the Biochemistry Department. "I was appointed temporary junior lecturer. Lower than that, you cannot start." From this lowest point, he has expanded outwards and upwards until reaching the status of Distinguished Professor with an NRF A-

rating since 1999. He has served many roles at the university, including Acting Head of Department (1991), Departmental Chair (1995 – 1998, 2002), Deputy Dean of the Faculty of Science (1999), and currently is the Co-Director of Stellenbosch University's Centre for Complex Systems in Transition. Hofmeyr's first transition in academia was from biochemistry to systems biology. Hofmeyr describes biochemistry as the most reductionist biological science. In the classic approach to understanding metabolic reactions, the building blocks and products of a single reaction are treated in isolation of the system that contains it. However, these reactions are rarely (if ever) isolated in a living system and have interactions influenced by factors at a reaction level, a cell level and an organism level. "You have to have an understanding of how all the pieces work together."

While he was grappling with this paradigm of biochemistry, Hofmeyr read a paper that changed his life. *The Control of Flux* by Henrik Kacser and Jim Burns (1973) described how the rate of a metabolic pathway could be influenced by the change in amount and activities of the enzymes in the pathway. The authors shared Hofmeyr's misgivings about treating metabolic systems and enzymes in isolation and attributing metabolic fluxes to a single, predictable control mechanism. "When I read that, I thought – this is mind-blowing, this explains most of what has been bothering me about the control and regulation of metabolic pathways."

The paper led Hofmeyr to become interested in the behaviour of biochemical systems and to understand what happens when systems are coupled together. To study these systems properly, he also bought his first computer (a ZX81 by Sinclair) and learned to code. "I realised you had to simulate the dynamic behaviour of metabolic pathways because it was very difficult, especially at that stage, to study it experimentally." He took the reductionist properties derived from biochemistry and tested how they behaved when put into a model.

EMERGING FIELD

The theoretical field that Hofmeyr entered was unnamed at the time. It later became systems biology. Hofmeyr remembers when there were only five or six people in the world with this focus. He brought this emerging field

into South Africa and established the first systems biology group, the Triple-J Group for Molecular Cell Physiology, dedicated to studying the control and regulation of cellular processes using theory, modelling and experimental approaches. "Systems biology was unique in South Africa, and then it became a huge thing internationally. It was the word you put in your grant proposals to get money; it was the cash cow."

Nonetheless, Hofmeyr seems to have outgrown systems biology. Over time, he saw the field fall into description rather than explanation. "The human genome project was this huge thing, it promised to tell us everything about life, which of course it doesn't." While it is important to look at the whole picture, seeing the whole picture doesn't necessarily explain the relationships between the individual elements. "What happened was all these high throughput technologies got developed. You can now measure virtually everything in a cell." Hofmeyr calls this system-wide biology and complains that just because you can measure it doesn't mean you know how it works and interacts with different elements in the system. "Systems biology needs a new view, a new way of looking at systems, not in terms of looking at the components, but looking at the relationships between."

This of course is the hallmark of complexity, where the relationships between components have characteristics that would not be predicted by looking at only the isolated parts. "If you have a system like that where the relationships are also important, then that system as a whole has properties that you cannot find in any individual component." This is what is described as emergent properties. Hofmeyr learned from complexity theory that while modelling may be helpful in some cases, modelling cannot always capture emergent properties.

Hofmeyr was introduced to complexity by Paul Cilliers. They became fast friends and were very interested in working together. However, the university was not an easy place to collaborate across faculty boundaries. "The snag was that I was in the Faculty of Science, he was in the Faculty of Humanities, and never the twain shall meet." Hofmeyr and Cilliers applied for funding for a Centre for Studies in Complexity. It started off with just the two of them and Rika Preiser as their research assistant. "The goal was to keep

it small and develop modules for courses that have to do with systems and complexity." One lecture they taught was called *Complexity – from Molecules to Morality*. "That's what you had to cover. It's a very broad topic." Although Cilliers passed away in 2011, the essence of his teaching can still be found embedded in the lectures Hofmeyr continues to give.

CHANGED BY A BOOK

In 1996, Hofmeyr was again changed by a book. He remembers walking into a local bookshop in Stellenbosch and stumbling upon a book called *Life Itself: A Comprehensive Inquiry into the Nature, Origin, and Fabrication of Life* by Robert Rosen (1991). "I had heard of him before because he had written a book called *Dynamical Systems Theory* which addressed the sort of things I had been doing with my modelling." Rosen, a theoretical biologist and trained mathematician, had written *Life Itself* as a pursuit of a central problem he had spent his career interrogating – What is the difference between living and non-living systems? The book is rooted in category theory, which Hofmeyr had to learn in order to really understand and appreciate Rosen's perspective. "That really took over my life. That's what I did in the evenings."

Reading the book changed how Hofmeyr viewed the complexity of life. "Even coming from a systems point of view, it was still so radical." The main lesson he derived from Rosen was that a living system is able to remake itself in the face of complete turnover. Living things are like factories that remake the entire factory floor from raw materials as every single instrument decays and all the machinery gets replaced autonomously without any help from outside. "We all know that, but we don't think about how special that is. That's what makes us different from the factories that we build. It means a very special functional organisation, fabricating itself as it goes along."

While Hofmeyr was inspired by this new outlook, he still had questions. Rosen had handled the concept in a very abstract way without getting down to the details of functionality. Hofmeyr saw that he could contribute to this understanding with his training as a biochemist. "I know what's inside cells, I want to know how self-fabrication works at that level." Hofmeyr's

excitement for the subject shows in how he describes it. "While you are sitting there, you are making yourself. Every part of you is fragile. You persist longer than any molecule in your life. In a year's time, virtually all of your atoms will have been replaced, but you will still be you."

In an attempt to address this gap between abstract and functional, Hofmeyr has come up with a new way of modelling. It's a linguistic model to describe and capture the functional organisation of life. He has just returned from overseas where he had dedicated his time to writing a book on the subject. While he wasn't able to finish his book, he has worked out the model and has presented it at conferences. He describes it as "a model that captures the idea of self-fabrication in terms of what we know happens inside the cell".

While much of modern science is geared towards application and improvement of society, Hofmeyr's contributions to biocomplexity and biochemistry are about improvements in thinking. "We are living creatures, we want to understand what we are." Hofmeyr explained that from the days of Descartes, machines have been a metaphor for life. Descartes was fascinated by hydraulic automata that mimicked living organisms. These automata can be interpreted in two ways. The first that automata are very life-like, or the second, that life is very automata-like and we are really machines. "Unfortunately he took the second route, but the other one is more obvious to me. These things simulate aspects of life, but of course we are much more complex than that." Regardless of how obvious it is, we have been living for centuries with the machine metaphor for life. "That makes you think about yourself and about other organisms in a particular way – which I think is very bad." Hofmeyr and others in his field have been turning that metaphor around and showing that life is a complex set of interactions that must be understood on its own terms.

Beyond the experimental and theoretical contributions, Hofmeyr has also contributed to the growth of a new generation of scientists through teaching and supervising. Another contribution is his building of spaces that facilitate the work of others. He has been instrumental in developing the Biochemistry Department, the Stellenbosch Institute for Advanced Study

(STIAS), and the Centre for Studies in Complexity. He has also helped to put together a proposal for the university's NRF Flagship Programme, the heart of which is a new research centre called the Centre for Complex Systems in Transition. The centre is dedicated to integrating the research fields of complexity, sustainability and transdisciplinary methodology and their application in water management, cities, renewable energy, and food systems. "For me, this is really about developing the platform for our fantastic young people to do their thing."

Hofmeyr wants young people to follow their dreams rather than be forced to conform to a particular way of thinking or a narrow area of study. "Don't let yourself be bamboozled into a straightjacket." He believes that you need dreams in order to pursue science and that pursuit must be framed by a question that drives the research. "Oh," he adds, "and learn how to write. Research is only half of the output. Reporting that research is the other half. Then, in a world where so much nonsense is written, try and maximise your signal-to-noise ratio."



| JONATHAN JANSEN |

TOP THREE AWARDS

- British Academy Nayef Al-Rodhan Prize for Transcultural Understanding, 2014
- ASSAf Science-for-Society Gold Medal, 2014
- Excellence in Education Award, Stanford Graduate School of Education, 2015

DEFINING MOMENT

On the first day as a Masters student in the USA, fresh from high-school teaching on the Cape Flats, my new professor at Cornell asked me to review his new manuscript before he sent it out for publication by a top academic publisher. That statement of confidence scared the hell out of me, but it also changed my sense of self forever. Until then, I had no great ambition and a very poor sense of self.

WHAT PEOPLE DO NOT KNOW

The public image of me is of a tough-minded, take-charge leader. Actually, I am a weak leader, I am emotional, I am led and taught by students, and I often change my mind.



THE TALENTED TRANSFORMER

Professor Jonathan Jansen doesn't enjoy being in the media limelight. "I used to, but now I think it's a drag," says the former Vice-Chancellor of the University of the Free State (UFS). The reason, he says, is that journalists often get the story wrong, and the wrong idea about him.

"They see me as this tough black guy who is in the spotlight a lot, who is into transformation and controversy." They don't appreciate his vulnerable side, or the aspects of his work that involve being a serious academic and scholar. Yet those aspects are central to Jansen's character.

By his own admission, he is a sensitive man. He takes his scholarly work into education and identity in post-apartheid South Africa very seriously. And despite his talent for delivering pithy media sound bites, he himself does not easily fit inside one. He resents being put in a racial or ideological box, such as 'coloured', 'liberal' or 'radical'. Such simplistic labels, he argues, are unhelpful as they are rooted in South Africa's troubled past.

EARLY LIFE AND EDUCATION

As for Jansen's own past, it was a combination of luck and drive that allowed him to rise above his lot. Growing up on the Cape Flats in the 1950s and 60s, he did not have a passion for learning. He ignored his schoolbooks in favour of cycling, swimming and soccer.

"I did not have any ambitions, because nobody else had ambitions where I grew up. I didn't know anyone in my family who went to university. My parents only made it to Standard 8. The best I could hope for, I thought, was to get a job and do as best I could," he says.

Then two things happened that shaped the course of his life. In his mid-teens Jansen caught the eye of the Latin teacher at his school. "He said to me, you pretend you know nothing, but you are actually very smart." This inspired Jansen to do better at school.

At the same time, he met a friend through church, who invited Jansen to study all night at his house. Jansen was happy to come around and sleep,

waiting for his friend's two-hourly food breaks to join in the snacking. But after a few weeks, he thought he would try to study too. The two kept it up throughout high school, and Jansen's grades – and appetite for learning – started to rise.

From his friend and his teacher, Jansen learnt two valuable lessons: The discipline required to succeed and the belief in his own intellectual capacity. "Many people didn't have those interventions, and ended up doing nothing with their lives. I was very lucky," he says.

Armed with his new sense of purpose, Jonathan Jansen applied and was accepted into university, and in 1979 he graduated from the University of the Western Cape with majors in botany and zoology. Aiming to become a science teacher, he then studied for a teaching diploma, which he received from the University of South Africa (Unisa) in 1982. Two years later he received a Bachelor of Education from Unisa in comparative education.

In the late 70s and early 80s he taught at Weston High School in Vredenburg on the West Coast, as well as at Trafalgar High School in Cape Town's District Six. He taught biology, and found he enjoyed it. In particular, he relished teaching children in Grades 10, 11 or 12, an age where he felt he was able to have a lasting influence. It is something he misses to this day, he says.

"By the time young people are at university it's often too late to change how they see themselves and their place in the world. I could go back to teaching kids tomorrow. If you have an impact on a poor kid's life then there's no better job," he says.

MOVE TO ACADEMIA

During the mid-eighties there was a feeling among some prescient folks in South Africa that the country might one day be free. Scholarships were set up with the leadership of people like Archbishop Desmond Tutu to train the black professionals needed to one day run the country when democracy became a reality.

Jansen heard about an opportunity for black South Africans to go abroad and study, and applied. He was in the second or third cohort that went to the USA as part of the Education Opportunities Council Scholarship Programme.

Jansen shipped off to the hallowed halls of Cornell University in New York State to study the cognitive psychology of education. The year was 1985, and Jansen was scared out of his wits. "The American students in my classes sounded like they knew everything. I felt really stupid," he says.

On trembling legs he went to meet his Professor Joe Novak in the legendary education scholar's – surprisingly modest – office. "You must be the man from Africa," Novak said. He then stood up to fetch a manuscript that was due for publication and handed it to Jansen. "I need your comments before I send it to the publishers," he said.

Jansen's jaw dropped. Here was the guru of his field asking a lowly graduate student's opinion on his latest work. Jansen read the manuscript what seemed like a million times. Yet, he didn't understand it. Panicking, he wrote down some comments and dropped it off with Novak's secretary, too scared to meet the professor in person again.

Only later in his life did Jansen understand what Novak had done by asking him to review the paper. The request had not been about testing Jansen's intellect, but making him feel included and valued for his academic contribution. This was a leadership approach that Jansen had not encountered in South Africa, where academic mentors had a tendency to exaggerate the distance between themselves and their students, a form of 'rule by fear'. As an academic mentor later in life, Jansen has tried to emulate the American approach with his own students.

Jansen's Masters degree at Cornell was by no means a walk in the park, however. Jansen still had to show up and work hard. His mentors would lose interest if he didn't. "I was up for the challenge. I slept very little. I discovered my potential and created scholarly habits. Things like being glued to a chair and finishing a book," he says with a laugh.

After graduating from Cornell in 1987 he was offered a doctoral scholarship to do a PhD at Stanford University in California, which he completed in 1991. His thesis was on curriculum transformation in Zimbabwe. The topic of educational reform during regime change would have echoes for his own country's transformation post-1994. He also got involved in university life, and was President of Stanford's African Students Association from 1988 – 89.

RETURN TO SOUTH AFRICA

Jansen enjoyed life in the United States, but there was never any question of remaining there for good. "In my generation, you didn't get a degree for yourself. You knew you had to plough back," he says.

After coming back to South Africa in 1991, he consulted for a short time for an American firm working with anti-apartheid NGOs. He later joined the University of Durban-Westville in KwaZulu-Natal as a Professor teaching curriculum theory, language and learning to undergraduate and postgraduate students. He became interested in the politics and ethics of knowledge.

At this time Jansen was inspired by feminist scholars like Sandra Harding and Evelyn Fox Keller, who made novel arguments, at the time, that since science dominated as it was by men had an inherent androcentric bias. Such theories about the scientific enterprise could be transferred to other types of knowledge, and to questions of racial transformation of South Africa's education system. He ended up contributing to education reform debates in South Africa, as well as to studies for international organisations like the World Bank and the United Nations.

He published his first book, titled *Knowledge and Power: Critical Perspectives across the Disciplines* in 1991, followed by *Implementing Education Policies: The South African Experience*, in 2001 together with Yusuf Sayed at Sussex University in the UK. Many more books were to follow.

In 2000, Jansen was appointed as the first black Dean of Education at the University of Pretoria. He wrote openly about his biography as a teach-

er and leader, and about the challenges that face black scholars in the academy. In his 2005 article *Black Dean: Race, Reconciliation, and the Emotions of Deanship* in the *Harvard Educational Review*, he discussed the tensions facing black leaders at white-dominated institutions, and the challenges of balancing redress with restoration, and reconciliation with social justice.

Jansen's willingness to tackle the most controversial aspects of education in the new South Africa in an accessible way led to invitations to write for the mainstream media. His collection of weekly columns for *The Times* newspaper were published in 2011 under the book title *We Need to Talk* and later in *We Need to Act*. Other general books Jansen has written targeting a non-academic audience include *Great South African Teachers*, written with students Nangamso Koza and Lihumelo Toyana.

His award-winning book *Knowledge in the Blood* (2009) explores how students on coming to school or university already carry 'bitter knowledge' of their racial past from a time before they were even born, and how the education system can deal with this.

BECOMING VICE-CHANCELLOR

In 2009, Jansen hit the headlines when he was appointed as the first black Vice-Chancellor and Rector of UFS, a former bastion of the apartheid state. The year before, a video filmed by four white students at the university humiliating black university employees had shocked the nation and raised new urgent questions about transformation in universities. The prob-

lem seemed very entrenched, and some said Jansen's job was impossible. Jansen tackled the challenge head on. In his inaugural speech he preached forgiveness for the four white students, drawing criticism from many quarters for being 'too soft' on racists, but receiving support from many more. To start with Jansen listened a lot, asking people from all racial and political camps what he could do for them. He pushed through some big reforms – such as the racial integration of university residences – but he did so while welcoming the opinions and voices of everybody in dialogue. After a while, some of the students who had been his most fervent critics were asking to be part of the solution.

Jansen has adopted a hands-on approach to transformation at his university. For six weeks after new students arrive, Jansen himself teaches them the first part of the university's new curriculum, focusing on how to deal with the country's violent past. He still faces a lot of criticism from across South Africa's political and racial divides. "Some in the new black leadership of this country think that I'm too soft on whites, that I'm not radical enough in my transformation work. But people on the other side say that I'm this black troublemaker who has it in for white people by moving too fast with transformation." It is all a matter of perspective, he says.

As for his own future, he isn't too sure yet. He probably will not retire in his current post. He is troubled by the persistently low and sometimes falling educational standards across the country. He would like to take what he has learnt at UFS and take it to the bottom 25% of schools across South Africa's nine provinces. "If we don't change the poorest schools we are in trouble," he says.

| TREFOR JENKINS |

TOP THREE AWARDS

- Biology Centennial Award for Science and Humanity
- Benjamin Pogrund Medal for Advancing No-Racialism, 1998
- Science-for-Society Gold Medal of the Academy of Science of South Africa, 2003

DEFINING MOMENT

Encountering sickle cell anaemia in paediatrics.

WHAT PEOPLE DO NOT KNOW

Collecting major historical scientific works dealing with South Africa.



A GOOD MAN IN AFRICA

When the Ford Foundation and the Oppenheimer Family Trust agreed, in 2004, to make a joint Endowment Grant to the University of the Witwatersrand (Wits) to found the Institute for Human Evolution (now transformed into the Evolutionary Studies Institute) the university set about finding a suitable Director for the institute. When the selected candidate (Dr Charlie Lockwood), who had been one of Philip Tobias' doctoral students, was killed in a tragic motorcycle accident in London, the university found itself in need of an Interim Director. Emeritus Professor Trefor Jenkins was asked, and agreed, to take on the position.

As the Ford Foundation Programme Officer responsible for the Foundation's portion of the grant, John Butler-Adam, Editor-in-Chief of the *South African Journal of Science* met with Jenkins on several occasions. At the end of each meeting, his first impression of Jenkins was reaffirmed: an accomplished scientist, a humanist, a wise manager, a kindly human being. In short, "A Good Man in Africa". But in this instance, a truly good man in Africa.

Jenkins was born in Merthyr Vale in Wales in 1932. In an interview with Professor Sir Peter Harper, he described his home town as set in the Taff Valley, not far from Cardiff, and his family as being "working class, the antecedents of Welsh miners". He attended the Quaker's Yard Grammar School, a few miles down the Taff Valley from his home in Merthyr Vale and on completing his schooling applied to study medicine at the University of Cardiff, the first member of his family to attempt to enter a university (or to succeed in doing so). He was, however, turned down, and so spent the following academic year doing two extra school-leaving subjects – botany and zoology (with a little extra physics) – and, in the next year, was accepted to study medicine at King's College London. Ironically, he was considered to be over-qualified to enter first-year studies, and so he was enrolled to undertake pre-clinical training at King's College, although his subsequent clinical training took place at the Westminster Hospital. Jenkins time at King's was enriching, "a fine education" in his own words and, like any self-respecting Welshman, he sang in the college choir.

After qualifying, he undertook his required house jobs at St Stephens Hospital and supported surgery for Dr Daryl Waters. On completing his housework, Jenkins started his national service in the army, which had a shortage of medical practitioners. He was, however, not good at marching (only Roger Bannister, his corporal told him, was as bad). Nor was he a good shot, and when told to aim higher, excused himself by saying "Look, I'm really a pacifist and trying to hit the target in the legs, not the heart". Completing his national service, Jenkins worked in two hospitals – focusing on obstetrics in one and in anaesthetics in the other as he had already decided that he wished to work in Africa, and felt that those two were areas that would most likely to be demanded of him. He first wrote to the Baptist Missionary Society asking if he could serve as a missionary doctor for three years, but the society indicated they would only consider his application if he were willing to devote his life to missionary work. Unwilling to follow this course, he was subsequently hired by Anglo American to work as a mine doctor.

His first posting was to the Anglo mine in Wankie, Southern Rhodesia (now Zimbabwe) where he was assigned to the paediatrics ward. Having no real experience in paediatrics, he was sent to the hospital in Livingstone (on the northern side of the Victoria Falls) where, in a week, he learned all he could and then returned to Wankie. In this work, it was his encounter with sickle cell anaemia in the paediatrics ward that turned out to be the first of the major defining moments in his life. He had never heard of the disease before and, fascinated by it, realised that he had a real interest in research as well as clinical practice. And that is where his research career, never encouraged in Britain, came to the fore and began to take prominence in his life.

RESEARCH INTEREST KINDLED

A medical technologist at the hospital taught Jenkins how to screen sickle cells on a slide and a fellow doctor, a graduate of the University of the Witwatersrand (Wits), told him about Wits. He contacted the Wits library and had bound copies of *the British Medical Journal (BMJ)* sent to him, "wrapped in brown paper" and learned as much as he could about the

disease, before undertaking field research (combining that with research on bilharzia) in the Zambezi Valley.

In order to continue his move into research Jenkins had, however, to break his contract with Anglo American before the end of his term – which meant that he and his wife would have to pay their own way back to London. While making arrangements for their trip, he met Denis Burkitt who was on “his famous tumour safari” as Jenkins puts it. Burkitt showed him photographs of a newly identified lymphoma/tumour – which Burkitt was sure would also be found in Durban as he had made an intuitive link between the tumour and malaria. So Jenkins and his wife routed their journey ‘home’ through Durban, where he had secured a surgery post as an interim measure, until his research could continue. On his first ward round, however, he identified cases of the very tumour he had seen in Burkitt’s photographs and so, in another defining moment in his career, Trefor spent a year finding and following up on Burkitt’s finding and publishing a paper – back into research.

One of his medical colleagues in Durban turned out to be a former Tobias student – who introduced the two scientists – and Tobias gave Jenkins a minor job as a “table doctor” in the Department of Anatomy at Wits. He did, however, continue his clinical work at the (then) so-called Non-European Hospital, where he worked with Harry Seftel.

As a result, his hospital work was not just further good clinical experience, but also turned out to offer him considerably more insights into a range of diseases that he had never before encountered. Being the insightful person he was, Philip Tobias offered Jenkins a longer-term lectureship, and he ended up undertaking field work for Tobias who, although it was not then his field, had realised that genetics was “the new anthropology”.

In 1968, Jenkins spent a year at Case Western Reserve University in the United States, working with Arthur Steinberg (famous for his work on the genetics of the immunoglobulins) and then returned to Wits, and set off on the research path that would ultimately lead to the establishment of the Department of Human Genetics in 1975, of which he was the Head.

The years between 1969 and 1975 were active years in Jenkins’ research career. His transition to human genetics came in 1969 when he took up the positions of Head of the Human Sero-Genetics Unit at the South African Institute for Medical Research (SAIMR) and part-time lecturer in human genetics in the Department of Anatomy. He was awarded an MD in 1973 and became a specialist pathologist (haematological), registered with the South African Medical and Dental Council (SAMDC), the same year. He was also an Honorary Geneticist at what is now the Johannesburg Hospital and at Baragwanath, and Senior Haematologist at the SAIMR. He won the Watkins-Pritchford Prize of the SAIMR in 1969.

In 1975, the new Chair of Human Genetics was created at Wits and he became the first incumbent, combining the management of the Institute with ongoing research. In 1978, he became the Associate Director for Research at the SAIMR and the Assistant Dean and, not unexcitedly, Student Advisor in the Faculty of Medicine at Wits.

Jenkins ‘retired’ in 1998 and subsequently became an Emeritus Professor and an Honorary Professorial Research Fellow in the Division of Human Genetics. During his retirement, he took an active interest in medical ethics and was appointed to a part-time post in the discipline at the medical school. He also played a major role in the establishment of the Institute for Human Evolution, and acted as Interim Director from 2004 to 2009.

Jenkins was a prolific writer: during his academic career, he published many papers, in peer-reviewed journals, as well as book chapters and books. Due to his extensive research record, he was awarded a Medical Research Council unit, with funding for three successive five-year periods from 1977 to 1993. His enormously successful Department of Human Genetics is still the largest in the country, expanding the staff, taking higher degree students and covering many aspects of the field from serogenetic, cytogenetic, clinical, epidemiological and psychosocial to the ethical, molecular and population genetics aspects. He also extended the laboratory, educational and clinical genetic services, and kept up to date with international developments in the field.

His educational interests led him to increase the contribution of genetics to the undergraduate medical student curriculum, while his enthusiasm for research led him to encourage his staff, colleagues and clinicians to pursue higher degrees in human genetics.

In his private life, Jenkins was a bibliophile, who spent time collecting major historical scientific works dealing with South Africa. One of his prize items, about which he often spoke, is John H Wellington's *Southern Africa: a Geo-*

graphical Study. Part 1: Physical Geography published by the Cambridge University Press in 1955. One of Wellington's reviewers has said of the book that "The classic monograph is usually seen as a methodological and conceptual break with the past, a work which introduces a new discourse and is ahead of its time. Yet the excellence of a classic can also lie in the fact that it is typical of its time and represents the best that was possible with the available knowledge and insights. Such a work was Wellington's *Southern Africa*."



| JOHANN LUTJEHARMS |

TOP THREE AWARDS

- Oceanology International's Lifetime Achievement Award, 2008
- European Geosciences Union's Fridtjof Nansen Medal, 2006
- National Order of Mapungubwe (Silver), 2000

DEFINING MOMENT

Dropping instruments into the waters west of Cape Town on an international research cruise in 1983 and discovering an eddy of Indian Ocean water that had 'leaked' into the Atlantic.

WHAT PEOPLE DO NOT KNOW

Lutjeharms published prolifically and loved to see his articles in print, particularly in high-ranking journals. He would update his CV every Friday, making sure to record any new citations his articles had received.



CHARTING THE AGULHAS CURRENT

On his first research cruise as a graduate student, Johann Lutjeharms swam in warm eddies off the east coast of South Africa. These mysterious gyrating patches of warm water were found far offshore, in water thousands of metres deep. He would not have known it at the time, but those swirls would later play a critical role in his career. By the time of his untimely death from cancer in 2011 he had become the leading authority in the world on the Agulhas Current that sweeps along the east coast of southern Africa.

During his career, Lutjeharms managed to revive global interest in the oceans and currents off southern Africa. By collaborating with key observational groups from all over the world, he was able to have a big impact despite having limited means. In total, he published eight books, 32 contributions to books, and 177 papers in peer-reviewed international journals. He was also a popular mentor and passionate communicator, sharing his insights with students and colleagues, as well as with communities living close by the ocean.

An adventurous spirit, he participated in a total of 17 research cruises. His work laid the foundation for understanding the role that the Agulhas Current plays in global climate and ocean dynamics. An iconic photograph depicts him on the deck of a ship surrounded by sea ice, peering at the horizon in his trademark beanie with a big grin on his face.

EARLY LIFE AND WORK

Paradoxically, for somebody whose life revolved around the ocean, Johann Lutjeharms grew up hundreds of kilometres from the sea. He was born in Bloemfontein in 1944 to an academic family. His father Wilhelm 'Willie' Lutjeharms had arrived in South Africa in 1937 from the Netherlands to become professor of botany at the University of the Orange Free State. As a boy, Lutjeharms attended the historic Grey College in Bloemfontein. In 1960, the family moved to Cape Town where Johann's father took up a Chair of Botany at the University of Cape Town (UCT). It was natural for the son to follow in his father's footsteps. Lutjeharms obtained his undergraduate degree in physics from UCT in the late 1960s.

As an Honours student, a visit to UCT's Oceanography Department sparked his interest in the subject, and he went on to obtain his Masters degree in oceanography in 1971. Thereafter, he received three bursaries – the Harry Crossley Bursary, the Fisheries Development Corporation postgraduate overseas bursary and the CSIR overseas bursary – to study abroad for a doctorate at the University of Washington in the USA.

Lutjeharms' PhD thesis described the dynamics of the Southern Ocean and was written under the supervision of James Baker, a famous American oceanographer. Baker later became Head of the US National Ocean and Atmosphere Administration (NOAA) during the Bill Clinton presidency.

After receiving his PhD in 1977, Lutjeharms returned to South Africa. He took up a position at the Council for Scientific and Industrial Research's (CSIR) National Research Institute of Oceanology, then newly established in Stellenbosch.

It was at this time that Lutjeharms began embarking on his famous cruises, often with the backing of international oceanographers and ocean modellers. He was particularly interested in the oceans around southern Africa, which were among the least studied in the world. Little was known about the Agulhas Current, more than that it flowed down the coast of Mozambique and South Africa. Nobody knew for sure what happened and at which point it intersected with the colder waters off the Cape of Good Hope, for instance.

Through his studies, Lutjeharms discovered that rather than moving like a conveyor belt along the southeast African coast, the Mozambique Current flowing through the Mozambique Channel was made up of swirls of water – the warm eddies he and his friends had swum in many years before – whirling south-and-west like waltzing couples before joining the Agulhas Current close to Richards Bay. This was a major discovery, which revolutionised the way the current was understood to behave and which has changed the face of all modern research in this area.

Lutjeharms also found that the Agulhas Current, after arriving near South Africa's southern tip, deflects back south and east in what is known as 'ret-

reflection', arriving back to its starting point in the Indian Ocean. In 1988 he coined the term 'the Natal pulse' to describe the large 'meander' in the Agulhas Current originating near Durban, which travels down the South African coast before turning away from the coast and returning up again.

THE 1983 CRUISE

His biggest discovery arguably came during a 1983 research cruise aboard the US Navy's research ship *Knorr*. The cruise surveyed the 'choke point' between Africa and the Antarctic, where the Agulhas Current meets the cold waters of the Southern and Atlantic Oceans.

The cruise was planned and executed with Arnold Gordon from Columbia University in New York City and Dutch ocean scientist Will de Ruijter. They knew that most of the water in the Agulhas Current deflects against the colder water and starts moving south and east back towards the Indian Ocean. But there was speculation that a small part of the current escaped round the Cape of Good Hope and joined the Atlantic currents heading north.

Gordon, who was chief scientist of the cruise, recalls the first moment the instruments were lowered into the sea west of Cape Town. The data revealed an ocean stratification not characteristic of the South Atlantic. It was an eddy of subtropical Indian Ocean water – but how did it get there?. This was proof, the scientists realised, that the Agulhas was leaking into the Atlantic. Measurements from the cruise estimated that 10–15 million tonnes of water travels past the Cape of Good Hope into the Atlantic every second. This is approximately equivalent to 10% of the total Agulhas Current.

The cruise team also established that this leakage was part of the global circulation associated with ocean overturning in the North Atlantic, commonly referred to as the Great Ocean Conveyor Belt. The observations ignited international interest in the Agulhas and its role in the larger-scale ocean and climate system.

Not content to rely on ship-based measurements only, Lutjeharms became a pioneer in the use of satellite data to model ocean systems. He published

papers in the 1980s that used thermal infrared data from satellites that he accessed through his contacts in the USA, as well as the CSIR's own Satellite Remote Sensing Centre.

He experienced first-hand the huge impact that advances in satellite technology had on oceanography – not least on navigation. On his first cruise as a graduate student, the crew still navigated by sextant, much the same as in the 17th century, and after a few cloudy days the ship would find itself hundreds of kilometres off course. Towards the end of his career, satellites were used to measure, to ever-smaller resolution, anything from plankton density to small variations in sea surface height.

KEY ACHIEVEMENTS

In 1990, Lutjeharms took up a Chair in Ocean Climatology at UCT, at the invitation of the then Head of Ocean Climatology, Geoff Brundrit. It was a post he held until his retirement in 2009.

In 1993, he also became the founding Director for UCT's Centre for Marine Studies, where he came to be known as a much-loved teacher and mentor. "He was a real father-figure to all of us," says Isabelle Anson, who worked with Lutjeharms at UCT from 1993. She says that he used his international standing and connections to create opportunities for his students to travel overseas, join research cruises and attend large international committees or workshops.

The book *The Agulhas Current* (Springer 2006) became his crowning glory; a definitive work on the subject informed by decades of study. The chapters of the book follow the current from upstream to downstream, charting the scientific understanding of the current but also detailing the explorers, ships and expeditions that contributed to the knowledge.

In the book, Lutjeharms describes how, as late as 1977, key textbooks in oceanography would describe the Gulf Stream in seven pages, while the Agulhas Current would receive two, brief paragraphs. He describes how the current connects major ocean basins, and how that makes it a

key area of study to understand the global weather patterns and climate change.

The book was widely praised as a seminal work, and in his review Lutjeharms' long-time friend, Will de Ruijter, called it "a must for everyone working in or on the greater Agulhas Current system".

OTHER INTERESTS AND LATER LIFE

Passionate about his Afrikaans heritage, Lutjeharms compiled a list of oceanographic terms for the leading Afrikaans dictionary, the *Woordeboek van die Afrikaanse Taal*. In addition to his other duties he was also a Fellow of the Royal Society of South Africa, a Full Member of the *Suid-Afrikaanse Akademie vir Wetenskap en Kuns* and also a Member of the Academy of Science of South Africa.

A prolific author, Lutjeharms often bragged that he had never submitted a paper to an academic journal that wasn't eventually published. To his close colleague Frank Shillington he confessed that he had studied at which time of year there was a drop in submissions to the journal *Science* – usually at Christmas time or during Europe's summer holidays! That's when he would submit his own manuscripts, to maximise his chances of publication.

Over his career he published two articles in *Science*, and five in *Nature*. In 2005, the *South African Journal of Science (SAJS)* lauded him as their most prolific author in the 25-year-period leading up to its centenary that year. He was also the author with the most SAJS journal covers in that period.

But Lutjeharms also cared deeply about communicating science with communities living in coastal areas, seeing them as a key part of the system he was studying. He was one of the brains behind the Agulhas and Somali Current Large Marine Ecosystems (ASCLME) project, which ran from 2008 to 2013. The project aimed to provide new information on ocean currents and how they influence climate, biodiversity and the economies of

the Western Indian Ocean. It developed a strategic action plan for the region to deal with trans-boundary threats, including unsustainable fishing practices and climate change. Nine countries bordering the Indian Ocean endorsed the plan on 23 June 2015.

Lutjeharms was diagnosed with cancer in late 2001. He fought the disease bravely, and managed to sustain an astonishing rate of scientific publications until his death.

Lutjeharms passed away on World Oceans Day, 8 June 2011 in his hometown of Stellenbosch. He was only 67 years old, but the disease had left him feeling old and tired before his time. His students travelled from near and far to pay their respects at the funeral service.

In the last two years of his life, despite being weak from surgery and chemotherapy, Lutjeharms undertook study trips to Europe and the USA. His final publication *Decay of Eddies at the South-West Indian Ridge*, written with students at UCT and the University of Southampton in the UK, was published posthumously on 3 November 2011 in the *South African Journal of Science*.

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| MALEGAPURU WILLIAM MAKGOBA |



TOP THREE AWARDS

- National Order of Mapungubwe (Silver), 2013
- ASSAf Science-for-Society Gold Medal, 2003
- The National Research Foundation President's Lifetime Achiever Award, 2011

DEFINING MOMENT

DPhil from Oxford, 1983 and work on cell surface adhesion/signalling at the NIH; a lifetime of effort towards transformation of higher institutions.

WHAT PEOPLE DO NOT KNOW

"Those who know me, think I should have been a comedian."

FROM SHEPHERD TO SCIENTIST

From humble beginnings as a rural shepherd boy, Professor Malegapuru William Makgoba has risen to rarefied heights as a distinguished researcher in immunology, a prominent and respected leader in higher education, and a vociferous advocate for public health and transformation in research and higher education.

Educated at the University of Natal Medical School (UNMS) during the era of Steve Biko and the Black Consciousness Movement, Makgoba spent some years abroad as an immunology researcher before returning to South Africa in 1994 to champion transformation in higher education. Since then, he has been responsible for several major research initiatives around HIV/AIDS, most notably the South African AIDS Vaccine Initiative. He was also outspoken against the disastrous policy of AIDS denialism during the 2000s, coming into conflict with some of the most powerful politicians in the country at that time. Recently retired from his ten-year tenure as Vice-Chancellor at the University of KwaZulu-Natal, Makgoba now chairs the Transformation Oversight Committee of Public Universities. Throughout his career, he has demonstrated the vision, courage and integrity of a great leader, with a clear passion for improving South African lives and a laser focus on equal opportunity for all.

As a young boy, Malegapuru William Makgoba would care for his father's sheep, goats, ducks and chickens after school. Surrounded by the hills of Limpopo, in the rural village of Sekhukhune, he would rest in the shade of a marula tree and ponder the wonders of the natural world.

This was indeed fertile ground for his enquiring mind, which eventually propelled him far beyond such humble beginnings.

"I suspect that the combination of my surroundings, loneliness, free time and all the animals that my father looked after, was a good environment in which to think about science as a discipline," he says.

Now an esteemed Professor, Makgoba completed his schooling in 1970, at Hwiti High School, which has since recognised his contribution to science and education by naming its science block after him.

STARTING REAL EDUCATION

He then enrolled at UNMS, where, he says, his real education began. "At that time, UNMS was a hive of political activity. You couldn't ignore it, it was always in your face; your classmates and other comrades were involved in it."

The racially segregated Durban Medical School, as UNMS was known upon opening in 1951, holds an important place in the history of apartheid South Africa. It was there that struggle stalwarts, such as Steve Biko, Mamphela Ramphele, Nkosazana Dlamini-Zuma, Ralph Mngijima and Aubrey Mokoape, first came together to stand against the institutional racism of the apartheid system. It was there that the South African Student Organisation (SASO) was formed in 1968. And it was there that the ideas behind the Black Consciousness Movement first took root.

For Makgoba, who describes himself at the time as "politically naïve", his time at Durban Medical School was characterised by a parallel education. "I was focused on my studies, of course, but I was also trying to familiarise myself with the political dynamics of the country. We were learning medicine, but at the same time we were being politicised." Steve Biko was President of the Student Representative Council (SRC) and Makgoba speaks of Biko and Barney Pityana (both a part of SASO leadership in the 70s) as his political mentors.

While he recalls his experience at Durban Medical School with happiness, it was a dark time in South Africa's history, which Makgoba only refers to off-handedly. "Of course, you always had the security police coming to raid you, wake you up in the middle of the night and search the hell out of you."

Historians speak of the unreasonable conditions that students had to work under, including discriminatory teaching practices, racist lecturers, poor living conditions and the countrywide restrictions for non-whites on services like public transport. It was undoubtedly a difficult environment in which to study, and thus no mean feat for Makgoba to have completed his medical degree with merit by 1976.

For 15 years following his time at the University of Natal, Makgoba worked abroad as an immunology researcher. His work focused principally on genes and cell surface proteins that are responsible for cellular interactions involved in the immune response – this research is still relevant today. He first went to Oxford, where he was a Doctor of Philosophy (DPhil) student under Sir Andrew McMichael, and one of the first researchers to clone and study a 'histocompatibility gene'. Such genes code for the cell surface proteins called histocompatibility complexes, which we now know to be major components of the immune response in all animals.

He completed his DPhil at Oxford in 1983, and promptly became first assistant to the President of the Royal College of Physicians, the late Sir Raymond Hoffenberg, working in clinical wards. "It was a good place to be, because every young physician wanted to work for the President of the Royal College of Physicians," says Makgoba. "I felt very privileged to be in that position."

Hoffenberg spoke very highly of his charge. "His research... is unquestionably outstanding. He has emerged as one of the best of the younger investigators in this country, which is absolutely remarkable when one considers the difficulties he must have encountered in his early training."

Later, at the National Cancer Institute in the United States (US), Makgoba and colleagues conducted high-impact research, particularly from 1986 to 1988, when the research group of which he was a part identified cell surface proteins that help immune system cells stick to and signal to one another, thus revealing a major feature of the human immune system that was previously unknown. "This work is still cited today, close to 30 years after being published. It changed the field." In fact, one of those published papers has been cited over a thousand times.

From there, he was headhunted to lead a research team at the Royal Postgraduate Medical School in London, where his group discovered that the proteins and complexes he had been working on in the US circulate in our bloodstreams. They showed that these molecules could be used to diagnose inflammatory diseases like cancer.

COMING BACK HOME

In the heady period following Nelson Mandela's release from Robben Island, Makgoba had a chance to meet the nation's hero in person. "He said to me," recalls Makgoba, "'I think you must come back home'." When the University of Witwatersrand (Wits) offered him the position of Deputy Vice-Chancellor in 1993, he did just that.

For the 22 years that followed his return to South Africa, Makgoba occupied positions of leadership in higher education. First at Wits, then at the Medical Research Council (MRC), and finally at the University of Natal (which later became the University of KwaZulu-Natal (UKZN)). He says the best part of being a Vice-Chancellor (at UKZN) was signing graduation certificates. "This wasn't in my job description, but it was the most fulfilling and rewarding, because signing a certificate of a student is an enduring thing. It's an honour."

Once, while at a New Year's Eve party at the Livingstone Hotel on the Zambezi, an old English couple bought him a bottle of champagne. When he asked why, they had said, "Because you hang in our house in England. You signed that certificate and graduated our daughter," he remembers gleefully.

Behind the man who had beaten the odds to rise to greatness, lies courage, passion and a drive to make a difference in the lives of ordinary South Africans, as demonstrated by his tireless efforts against the scourge of HIV and AIDS.

While at the MRC, Makgoba had pioneered the South African AIDS Vaccine Initiative (SAAVI), which continues to fund South African research into an HIV vaccine. "It's a big project and a necessary project," says Makgoba. "As a developing or middle-income country, you want to have the capacity and the flexibility to adapt research to deal with the issue at hand." SAAVI has produced several prominent female researchers such as Professor Lynn Morris (National Institute for Communicable Diseases), and Professors Anna-Lise and Carolyn Williamson at the University of Cape Town.

Makgoba was also the founding Chair of the UNAIDS/WHO African Aids Vaccine Programme during his time at the MRC. But perhaps his greatest achievement in this arena was during the era of AIDS denialism, synonymous with President Thabo Mbeki's leadership during the early 2000s. Despite overwhelming evidence to the contrary, the South African government took the official stance that HIV does not cause AIDS. Makgoba took a very vocal and public stand against this disastrous policy, which, some researchers estimated, cost over 350 000 lives.

"I've never felt that I was more needed to save the lives and dignity of people than during that period of AIDS denial," he says. A comment by Justice Edwin Cameron on Makgoba's role in fighting AIDS denialism deserves repeating in its entirety. "The clarion voice of truth speaking amidst the siren clamour of unscientific waywardness earned Makgoba few friends in the political establishment. But it enhanced his standing as a medical scientist faithful to his discipline and to canons of scientific enquiry. In taking this stand, Makgoba occupied a unique position in South African public life. His professional eminence in the field of immunology, his profile as a public intellectual, and his passion for truth combined to an extraordinary degree at a moment in which a nation searched for answers."

And as if this wasn't enough to secure his place as champion in the fight against HIV/AIDS, his contributions to South African research in the field surely does. Using relationships formed while abroad, Makgoba was instrumental in securing major international funding to set up the Africa Centre and the KwaZulu-Natal Research Institute for Tuberculosis and HIV (K-RITH), funded by the Wellcome Trust and the Howard Hughes Medical Institute, respectively.

Combined with the CAPRISA initiative funded by the National Institutes of Health (NIH), all located in an area of high HIV/AIDS prevalence, these institutions represent possibly the largest coordinated HIV research effort in the world. Makgoba remains humble about the success: "There were challenges in terms of the health of the country that related to what I would call

my passion, and of course when you do these things that require big money, people have to trust you. I enjoyed the trust of my colleagues that I had worked with abroad, and I used that to the advantage of the university."

If there's one other thing that Makgoba will forever be remembered for, it's his passion for transformation in higher education in South Africa. "Since my arrival," he says, "part of my success story has been transformation of research institutes and higher education institutes; it defines who I am." In 2013, he received the National Order of Mapungubwe bestowed by the President in recognition of his herculean efforts at institutional transformation, and, largely thanks to him, UKZN is now the most transformed institution in South Africa.

Despite these successes, Makgoba believes South African research still has a long way to go to reach its potential. "I want to see South African research transformed in a very meaningful and substantial way, such that we give all those with potential the opportunity to succeed. Their success is our success as a nation."

Though he recently retired as Vice-Chancellor of UKZN, he continues to push the transformation agenda as Chair of the Transformation Oversight Committee of Public Universities. He is also the Deputy Chair of the second National Planning Commission, having served on the first one since 2010 under then-Minister Trevor Manuel.

He has also recently been appointed the first Health Ombudsman for South Africa.

And so, while he is taking a step back from the very public role that he has played in the country's health research and in higher education in general, Professor Malegapuru William Makgoba will be remembered as a leader in thought and in action; a man of courage, integrity and ironclad resolve to do the right thing. Now retired to his childhood home of Sekhukhune, this great South African mind will continue to improve South Africa for years to come through his thoughts, his words, and most importantly, his deeds.

| WALTER FRIEDRICH OTTO MARASAS |



TOP THREE AWARDS

- A appointment as a member (foreign associate) of the National Academy of Sciences (USA), 2008
- Two Honorary Doctorates – one from the University of the Free State and the other from the University of Pretoria.

DEFINING MOMENT

The part he played in discovering the role of the fungal toxin *Fumonisin* (*Fusarium moniliforme* toxin) and defining its role in human and animal health.

WHAT PEOPLE DO NOT KNOW

He was a passionate philatelist and botanist, avidly collecting stamps depicting flowers and fungi that he classified botanically and mycologically. He sadly did not live to see the publication of his book *Philatelic Mycology*.

ZOOMING IN ON MYCOTOXINS

Walter Friedrich Otto Marasas was born on 25 October 1941 in Boksburg, South Africa. In 1962, he graduated from the University of Pretoria (UP) with a BSc in agriculture (plant pathology and botany), followed by an MSc in agriculture (plant pathology) in 1965, while lecturing and conducting research in the field of mycology. Having developed an interest in the mycotoxins produced by fungi, as well as the human and animal diseases associated with these toxins (a topic which had not yet been researched extensively in South Africa), he enrolled for a PhD in plant pathology at the University of Wisconsin in the USA, graduating in 1969.

In 1975, the family relocated to Cape Town, upon Marasas' appointment as Chief Specialist Scientist of the Programme on Mycotoxins and Experimental Carcinogenesis (PROMEC). This was based at the Medical Research Council (MRC) in Tygerberg, where Marasas was able to develop his research focus on mycotoxins with the potential to affect human health. He later became Programme Leader and in 2001, was promoted to the position of Director of the PROMEC Unit. He would remain at the MRC until his retirement in 2006.

A leading authority in the field of mycology and mycotoxicology, Marasas focused particularly on the taxonomy and biology of genus *Fusarium*, a common maize-infecting fungus, and the range of diseases which could be transferred to humans and animals in food and feed as a result of *Fusarium* toxins. In addition to this, he was able to contribute to the classification and description of numerous other toxigenic fungi – both in South Africa and internationally. Over the course of his career, he was instrumental in the classification of 34 taxa. Two taxa were also named in his honour: *Mycosphaerella marasasii* and *Pseudocercospora marasasii*.

INITIAL INTEREST

His initial interest in the mycotoxins of *Fusarium* began when he observed cases of equine leukoencephalomalacia (LEM), leading to brain damage of diseased horses. This he believed to be the result of the ingestion of infected maize. Many years of intensive research at the MRC laboratories in Tygerberg enabled this hypothesis to be proved, although the specific tox-

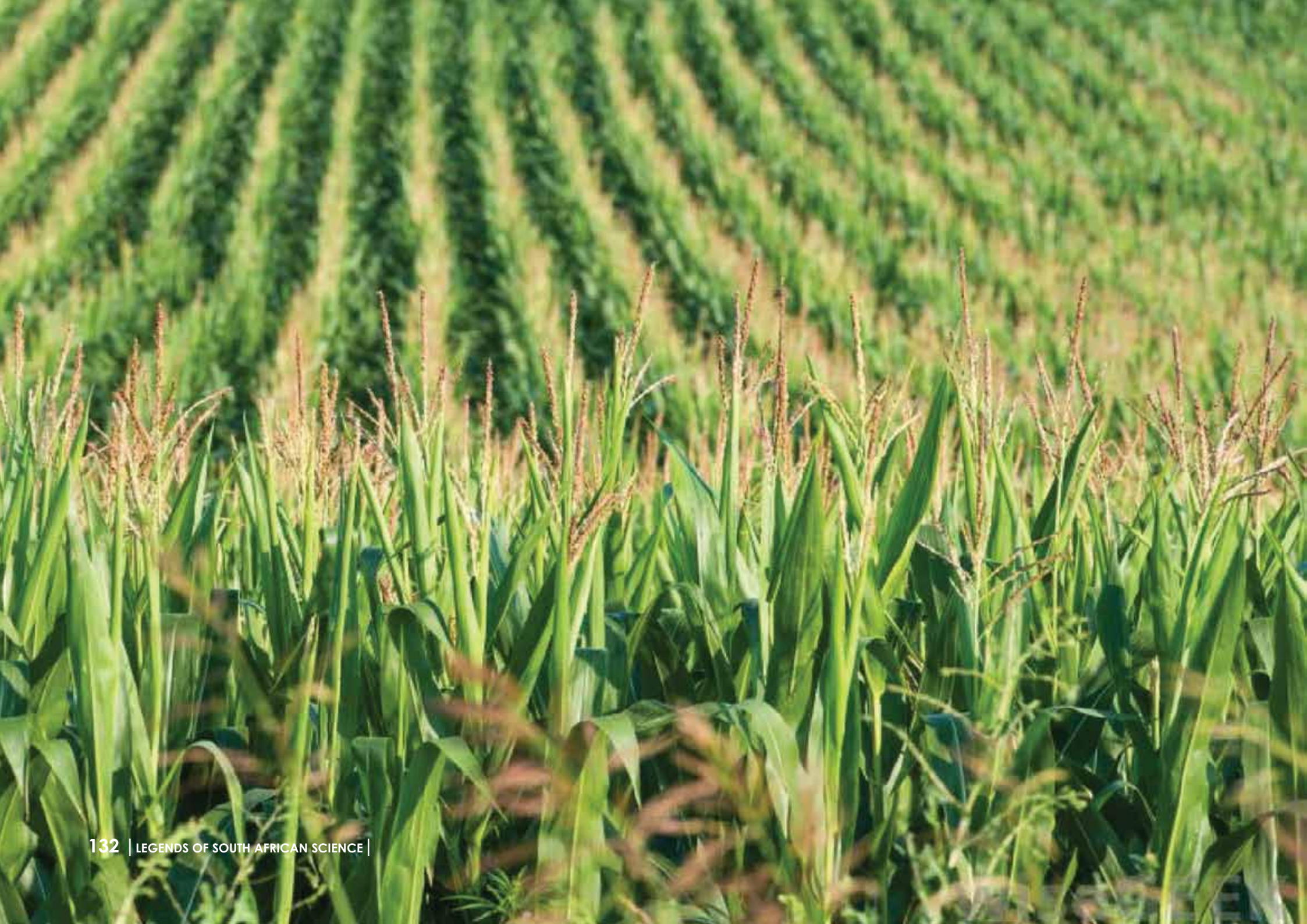
in responsible had not been identified. After over 20 years of concentrated research by Marasas and his team, the mycotoxin named Fumonisin (from *Fusarium moniliforme* toxin) was identified and characterised. This momentous discovery led to international recognition of the team responsible, and fumonisin became the subject of much research across the globe.

Having identified Fumonisin, the next phase in Marasas' career was to investigate its potential consequences for human health. Findings pointed to the likelihood of this toxin being related to oesophageal cancer, pinpointing cases within the population of the Transkei, where the rate of occurrence was shown to be one of the highest in the world. These cases appeared to be linked to infected maize supplies, a dietary staple in the region, as well as traditionally being used to brew beer.

Subsequently, these findings played a definitive role in the advancement of human health in South Africa and other emerging regions, assisting in the development of risk analyses of food standards for groups such as the World Health Organisation (WHO).

While Marasas spent most of his career as an active researcher at the MRC, he also held a number of visiting appointments. From 1977 until 1978, he was a Visiting Scientist at the *Bundesanstalt für Fleischforschung* based in Kulmbach, Germany. 1981 saw him in the USA, acting as Visiting Professor at the Department of Plant Pathology of Pennsylvania State University. This was followed by an appointment as a Pawlett Visiting Scholar in the Department of Plant Pathology of the University of Sydney, Australia. He returned to the USA in 1992 as a Visiting Professor at Kansas State University in their Department of Plant Pathology. He maintained close ties with Pennsylvania State University, where he was named Adjunct Professor in the Department of Plant Pathology, as well as Kansas State University. He was also appointed as a Distinguished Professor in the Department of Microbiology and Biochemistry, at the University of the Free State in 1989.

In 1998, he was recognised by his *alma mater*, UP, where he was appointed as Extraordinary Professor in the Faculty of Biological and Agricultural Sciences. This honour was also accorded him by Stellenbosch University,



as Extraordinary Professor in the Department of Plant Pathology. Although not based at an educational institution, he was able to make an important contribution to the training of a new generation of scientists in this manner, supervising and sometimes co-supervising some of the leading students of microbiology and plant pathology. He also played an active role in encouraging students from other African nations to continue their studies in this field.

Throughout his career he was esteemed by the scientific community, and held a number of honorary positions. In January 1991, he was made a Fellow of the South African Society for Plant Pathology. International exposure following his work in describing the effects of mycotoxins led to his appointment in 1995 as Expert Consultant to the Joint Food and Agriculture Organisation (FAO)/WHO Expert Consultation on the Application of Risk Analysis to Food Standards Issues by the World Health Organisation, based in Geneva, Switzerland.

Other professional societies he was part of were the International Society for Plant Pathology, where he was involved in committees on mycotoxicology and *Fusarium* respectively; the Southern African Society for Plant Pathology; the South African Council for Natural Scientists. He was also deeply involved in the Pan-African Environmental Mutagen Society (PAEMS), of which he was President between 1995 and 1999.

In conjunction with his research work, Marasas published extensively, and attended a variety of conferences, delivering more than 190 papers throughout his career. He authored three monographs on the topic of *Fusarium* and mycotoxins. These are generally considered to be definitive works in their field. In 2002, data from the Institute of Scientific Information showed that he is also one of the most cited scientists in the world in two categories: agriculture, and plant and animal sciences.

His longstanding contributions to plant pathology were recognised locally and abroad, when in 2001, he was made an Honorary Member of the Southern African Society for Plant Pathology. A Fellowship of the American Phytopathological Society followed in 2005; he is one of only two South Africans who has achieved this.

In spite of his great success as a scientist, and the numerous accolades garnered throughout his career, Marasas is remembered as a humble man of integrity with a “typical South African sense of humour” (in the words of Prof Michael Wingfield, a former student). He was passionate about his chosen profession and worked hard to make a contribution to the community. Together, he and his wife were frequent visitors to the Nieuwoudtsville area of the Namaqualand, where Marasas enjoyed studying the indigenous flora. He passed away in 2012 at the age of 70, mourned by his wife, children, grandchildren and his close friends in South Africa and throughout the world.

He was also a passionate philatelist, collecting myriad stamps, particularly focusing on those depicting fungi and flowering plants. At the time of his death, he had been compiling a book with some of his most cherished specimens – a project which was then taken up by his wife Rika in collaboration with Professors Michael Wingfield and Pedro Crous. Rather than organising the book according to the usual philatelic method of country and year of issue, over 1 000 stamps were classified according to the taxonomic groups to which the fungi depicted belong. The book, titled *Philatelic Mycology: Families of Fungi*, was completed in 2013. It was published by the CBS-KNAW Fungal Biodiversity Centre in The Netherlands – a fitting tribute to this distinguished scholar, bringing together the love of the man for the field to which he dedicated his career.

With acknowledgement to Prof Michael Wingfield.

| TSHILIDZI MARWALA |

TOP THREE AWARDS

- National Order of Mapungubwe (Bronze), 2004
- National Research Foundation President's Award (P-Rating), 2003
- Being elected to The World Academy of Sciences, 2010

DEFINING MOMENT

"The birth of my three children, and meeting my wife Jabulile."

WHAT PEOPLE DO NOT KNOW

"I run every morning for 30 minutes."



FROM BIG CITY TO BIG SCIENCE

In a time when “ozone layer” and “superconductivity” were the buzzwords of modern science, matric pupil Tshilidzi Marwala found himself in London, the biggest city he had ever seen, and a setting worlds apart from his home town of Duthuni, Venda.

“Everyone was talking about eliminating friction so that trains would use very little energy. And we didn’t know what climate change was yet – the big issue discussed by the British Minister of Science and Technology at that time was the ozone layer.”

It was 1989 when he was at Mbilwi Secondary School, and part of a group of elite students from across the world. He was chosen because he was a finalist in the National Science Olympiad.

“My prize,” says Marwala, now a Professor serving as the Deputy Vice-Chancellor of Research, Innovation, Postgraduate Studies and the Library at the University of Johannesburg (UJ), “was a fortnight’s visit to Britain’s capital”.

Reflecting on his life’s journey from the couch of his office, he notes that this overseas trip was preceded by a week-long visit to Johannesburg to attend National Science Week – the “biggest city he had ever visited” for about a week before going to London.

“I didn’t understand the cold war or other big global issues. And I didn’t know what engineering or artificial intelligence was. But it was during this excursion, while staying at the University College London and visiting Oxford University, that I decided to spend the rest of my life in science and technology.”

He returned to South Africa certain of two things: he would study science, and he would study outside South Africa. Unfortunately, on the train back to Venda to write his matric exams, he was robbed.

“When I arrived home I was barefoot, and I did not have a single picture from my trip. They took everything.”

But life went on, and for the rest of his final school year, he wondered how he would be able to go overseas to study.

Then in December the letter came: “You are going to St John’s College in Johannesburg to do your British A-levels”.

Marwala went, completed his A-levels and then set off to the University of Cape Town in 1991 to begin a degree. In March that year he once more received a letter with a study opportunity in Ohio in America.

“I had never heard of that place. I thought it was pronounced “oh-hee-oh”, rather than “oh-high-oh”, he remembers with a chuckle. “They gave me the name and location of the university, but without Google there was no way to get more information other than going to the American embassy to pick up a big book of US universities.”

Four years later, Marwala returned to South Africa with a BSc in mechanical engineering (*magna cum laude*) from Case Western Reserve University. He briefly worked at the Council for Scientific and Industrial Research (CSIR) before getting a call from his mother.

“She said she had received a letter from a Professor Stephan Heyns at the University of Pretoria, requesting that I come and see his lab. So I went, and I decided to do my Masters in mechanical engineering there.”

MULTIPLE DISCIPLINES

Thereafter, Marwala again left South Africa to complete a PhD in artificial intelligence at the University of Cambridge, London, where it all began back in 1989.

He believes in the value of being multidisciplinary. During his own undergraduate degree in America, Marwala had dipped his feet in the waters

of psychology, history, economics and even acting, despite majoring in engineering. It was this broad, multidisciplinary grounding that eventually led him to what has become the scientific buzzword of our time: artificial intelligence.

"The books I have written are in diverse fields. There is artificial intelligence in everything I do, but it is multidisciplinary." Indeed, Marwala's work has covered topics from economics, as in his recent book *Economic Modelling Using Artificial Intelligence Methods* (2014), to military conflicts, as in *Militarised Conflict Modelling Using Computational Intelligence*, which he co-authored in 2011.

After his PhD, Marwala went on to complete a postdoctoral fellowship at the Imperial College, London, as well as a leadership development course at Harvard Business School. Yet before settling into his career as an accomplished academic, an esteemed author and a beloved mentor to his students, Marwala returned to South Africa to brew beer at South African Breweries (SAB).

To be more specific, he developed an artificial beer taster to evaluate the quality of beer.

"When someone tastes a beer they are tasting all the chemical components – the water that has gone into it, the ingredients, everything," he explains. "How those chemicals come together is important because it affects the pH (acidity) of the beer, the colour and other parameters."

"If you brew a beer and it comes out green it will probably taste different to a golden beer, so colour, for example, is a very important marker of how a beer will taste. And a beer is a system, so if one of the parameters is off, the others are bound to be off as well."

The common approach to assessing beer quality is for human tasters to taste the beer each morning and assign to it a score based on taste and on parameters like colour and pH, which can be measured using various equipment.

Applying artificial intelligence to this essentially means creating an automated system that can predict what score a human taster would have assigned to the beer. To do this, the measured parameters are compared with a huge database of previous scores given by humans. And even though humans have mood swings that could affect scoring, a large enough database will allow an artificial system to generate good predictions on average.

The best case scenario is that an artificial taster becomes more accurate than using human tasters, but it can at the very least be used to supplement quality control tests by humans.

"Theoretically, the artificial beer tester is a machine one can put into a freshly brewed barrel, and which then gives you a statement of how good the beer is based on measured parameters. But removing humans from the process is not done lightly, and there are many safety concerns that need to be satisfied," explains Marwala.

He was involved in the research and development process to generate a prototype, and then moved on to the University of the Witwatersrand (Wits) to continue his academic career.

"The six-and-a-half years I spent at Wits was a very rewarding time. I met a lot of young people, supervised a lot of students," he says.

In fact, Marwala has supervised 19 doctoral students to completion, as well as 47 Masters students, many of whom have gone on to their own successful careers.

"A former student got his PhD from Cambridge, one got a DPhil from Oxford, and another went to Harvard to complete a postdoctoral fellowship," says Marwala. "I had very good students, from South Africa, Africa and the rest of the world – I'm very lucky to work in a field with a public profile, a field that certainly attracts many good students."

He explains that in the 90s, many people thought artificial intelligence, or AI, was just another buzzword that would over-promise and under-deliver,

and eventually disappear. "But just look at the Google search engine," he says.

ATTRACTING STUDENTS

Since joining UJ in 2009, as the Executive Dean of The Faculty of Engineering and Built Environment, and now in his current position, students from countries as diverse as Jordan, Brazil, China and India have requested to study under him.

"This is the most exciting part for me. It enriches our lives, it exposes us to different cultures and views. When I was an undergraduate student, yes it was cosmopolitan, but it's different when you are a mentor or supervisor. I am fully responsible for those students' stipends, accommodation and well-being, almost like a parent.

"Of course there are difficulties – students get distracted, and you have to push them. But it's fulfilling; it's like travelling the world."

Marwala is not just in demand when it comes to students. "I get all sorts of requests from all over the world, for advice for instance, even from places I thought to be the centre of research in this field."

He points out that such requests began in earnest when he started writing books. "What I've realised is that books make more of an impact than journal papers," he explains. In addition to the over 250 peer-reviewed journal articles, popular science articles, conference proceedings and book chapters Marwala has contributed to, he has authored or co-authored

nine books to date, and one of his proudest achievements is having had one translated into Chinese.

And this articulate writer is also an avid reader. "I like reading outside artificial intelligence, but also non-fiction. In fact I can't recall the last time I read fiction, except maybe Julius Caesar," he says light-heartedly, adding that he particularly enjoys books on the history of science, such as two recent additions to his library, *Sapiens: A Brief History of Humankind* (2014) by Yuval Harari, and *Guns, Germs, and Steel: The Fates of Human Societies* (1997) by Jared Diamond.

When he is not reading, writing or supervising students, Marwala manages research at the university, which involves creating strategies and conditions for academics to fund and conduct their research. He has been in this office for the past three years, and sees his role as ensuring that the University of Johannesburg becomes a leading research institution.

Asked if he still has contact with any of the people he met on that first serendipitous trip to London, Marwala says not really; only a few exchanges here and there over the years. One of these exchanges was a letter that arrived sometime after Marwala had come home barefoot without his belongings in 1989.

It was from a Chicago student who had been in London with Marwala. In the envelope were two photographs of Marwala and the group, so despite the mugging, he does at least have some souvenir of one of the first steps on his journey to success.

| BONGANI MAYOSI |

TOP THREE AWARDS

- Order of Mapungubwe, Silver (Medicine), 2009
- South African Medical Research Council's Platinum Award, 2016
- National Research Foundation A-rating in recognition of world-leading research on poverty-related heart disease, 2016

DEFINING MOMENT

Sitting in the back of my father's Land Rover, driving to see patients in his district in the Eastern Cape. I always wanted to be a doctor like him; it wasn't even a decision I had to make.

WHAT PEOPLE DO NOT KNOW

My wife and I used to be competitive ballroom dancers. We danced for Wolfson College at Oxford University, and in 1999, we were part of the dance team that won the Oxford Cup.



KING OF HEARTS

The son of a district surgeon and a nurse, Bongani Mayosi was always going to study medicine. His father, George, had been in the early group of doctors to graduate from the University of Natal's 'black' medical school in Durban, which opened in 1947. George specialised in obstetrics after working as a district surgeon for the small hamlet of Ngqamakwe in the Eastern Cape. This is where Bongani grew up, surrounded by the rolling hills of the Transkei.

Bouncing along the potholed roads in the back of his father's Land Rover, Mayosi had an early introduction to the routine life of a doctor. His father would pull up outside a shop in a nearby village and set up a makeshift clinic. As for his education, his parents saw to that – and to that of the rest of the children in Ngqamakwe. When the Mayosis arrived, the closest school was a long walk away in a nearby village of Ngculu. But Mayosi's mother had trained as a teacher before re-schooling as a nurse, and with the help of other parents in the village they set up a school in the hamlet. The school took in every child able to walk in the village in order to make up numbers. Different grades were taught in one large church hall. It was an excellent environment for learning, Mayosi recalls. His whole generation graduated in their mid-teens, earlier than they would have at a more formal school.

Once out of school, Bongani followed in his father's footsteps and went to study medicine at the University of Natal. Competitive by nature, he wanted to exceed his father's accomplishments. He discovered that the school made provision for students to earn a research degree after their third year of medicine. Few people used it – after all, it meant losing a year's earnings as a qualified physician. But Mayosi was able to convince two of his professors to take him on as a student: one a professor of anatomy, the other a pharmacology professor. That was when the joy of discovery seized hold of Mayosi.

"I spent a year studying the small navicular bone in the human foot. Seeing my work published, and defending it, was a wonderful experience," he says.

After graduating with distinction from the Bachelor of Medical Science degree in 1986, Mayosi went back to finish his medical degree, also with distinction. He left medical school in 1989 and went for a residency in Port Elizabeth. It was meant to be a temporary move away from Durban, which had become home. At PE's Livingstone Hospital he met a group of people hailing from Groote Schuur and the University of Cape Town (UCT).

"They kept going on about the place, and I wanted to come see what it was all about before returning to Durban," he says. He and his wife both held the Cape dear, having spent their honeymoon there some years before. "We'd already fallen in love with the geography," he says. And the medical research community seemed to brim with opportunities for the ambitious couple, so they decided to move there.

DECODING SUDDEN HEART FAILURE

Mayosi started off in Groote Schuur's Division of Neurology. But during his rotations at the hospital he fell in love with cardiology. It was a discipline of some renown in the hospital, which was the setting of the world's first human heart transplant in 1967 under the deft scalpel of Christiaan Barnard.

One of the first clinical problems to tickle his mind was that of unexplained heart failure. That is where a young person comes to the clinic very sick with shortness of breath, a swollen body and enlarged heart. The phenomenon was not understood at all, but Mayosi had a hunch there could be a heritable factor at play. And so he started assembling samples from families where several members were affected.

In 1998, six years after joining UCT, Mayosi boarded a plane bound for the UK to take up a doctoral post at the University of Oxford. His luggage held eight samples from a family affected by sudden unexpected death due to an unexplained form of heart muscle disease called arrhythmogenic right ventricular cardiomyopathy (ARVC). Initially, he hoped that his PhD could identify the genetic variant that caused the illness in this family. But the technology of the time, even at Oxford, was not sufficient to draw good

conclusions from so few samples. When he returned from South Africa five years later, the family samples returned with him, unstudied.

Instead, Mayosi spent his time at Oxford studying conditions where genetics may be one of many factors causing disease. For instance, a thick heart is more likely to develop cardiac arrhythmias. High blood pressure is one of the known reasons why the heart thickens. But there are other factors, such as genetics.

"What I had to work out in my PhD was the proportion of the variability of heart muscle thickness that is influenced by genes. It was a wonderful project, and intellectually more stimulating than the one I came to Oxford wanting to do," he says.

It took another 15 years for Mayosi and his colleagues to crack the conundrum of his patients with ARVC. When he returned from Oxford he recruited his first postdoc to work on the problem at UCT. A wrong turn in the genetic analysis led the team to study the wrong part of the chromosome for seven years. Then the advent of exome sequencing allowed for improved analysis, and in March 2017, the team finally published a paper identifying the culprit: A mutation on a gene called *CDH2* (N-cadherin), which increases the risk of heart muscle disease and cardiac arrest.

The discovery was "probably the biggest breakthrough in South African cardiology since Dr Chris Barnard's first heart transplant," Mayosi told the media at the time. In addition to being a first on South African soil, the gene codes for a protein that has not been linked to heart disease previously. The next step is to understand how, biologically, the mutation causes the condition. Once that is understood, it could lead to completely new treatments for heart muscle disease and sudden death. Mayosi relishes the challenge that lies ahead. "We're at base camp. Now we have to ascend Mount Everest."

A FAMILY AFFAIR

In 2016, Mayosi received an A-rating by the National Research Foundation, identifying him as a world leader in research on heart diseases related to poverty. He studies pericardial tuberculosis (TB), caused by *Mycobacteri-*

um tuberculosis, the bug that causes TB. Pericardial tuberculosis is the most common form of pericarditis – inflammation of the heart sac – in Africa and other places where TB rates are high, especially as a result of widespread HIV infections. The condition causes chest pain, can disturb the heart rhythm and even cause death.

Mayosi's team have defined how pericardial TB presents in the HIV era, how to diagnose it and how to treat it. "That work has redefined the field of pericardial TB in the world." He has also worked on the prevention of rheumatic heart valve disease by setting up the first multinational studies with colleagues from all over the world.

Another breakthrough came from working with his wife, a dermatologist and fellow UCT professor. Together they have studied a family with a rare condition that mottles and scars the skin of its sufferers. So far, they have identified the gene that causes the condition, something that could be interesting for a range of other illnesses, Mayosi says. Scarring is a common complication of diseases like TB, heart disease and liver disease. TB scars the lungs, heart attacks scar the heart and cirrhosis scars the liver. This scarring can lead to problems down the line. Mayosi hopes that by understanding the genetic cause of the rare skin disease studied with his wife, they can shed light on ways to prevent scarring in general.

But life is not just about battling disease. Mayosi's pride and joy are – literally – his two daughters, Vuyi and Gugu. "Vuyi means joy and Gugu means pride," he explains with a smile. Vuyi, the eldest, has finished medical school and is a first-year intern in Johannesburg. She is a third-generation doctor. Gugu is at UCT studying occupational therapy in her fourth year.

A BRIGHT FUTURE

Mayosi became head of the UCT Department of Medicine in 2006. He's a member of numerous national and international learned societies, including the Royal College of Physicians of London and the American College of Cardiology.

He has also bagged several prestigious research grants for UCT and his department, earning over 100 million rand in total since 2010. In 2016, he won

a 15 million Rand grant focusing on non-communicable diseases from the Newton project, a collaborative funding programme between the governments of the UK and South Africa to strengthen research links between the two countries. In 2013, he led a team that received a whopping 34 million Rand over 42 months from the H3Africa programme, an initiative to build genomic research capacity in sub-Saharan Africa. That same year he obtained a 23 million Rand grant from the South African Technology Innovation Agency, the National Research Foundation and other funders to buy a whole-body magnetic resonance imaging scanner for use in research.

Given that he only turned 50 in 2017, his achievements so far are impressive. So what is left?

Apart from continuing to chip away at his research projects, he wants to feel when he hangs up his lab coat in a decade or two's time a sense of 'completeness'. "I want to pursue a total academic career. I want to play a role in leadership and administration, in research, and also in national and international life." Most importantly, he wants to continue to be useful and to break new ground in global medical knowledge.

"My career has been a little unusual. I've tended to go for research niches that are under-occupied, where my group might even be alone in the world to study a particular question." That means he can take his time compared with colleagues in more popular fields, where regular publications are vital to keep up with the competition.

"From that point of view our work on the heart muscle disease gene could be considered a failure!" he says. After all, the team only produced two papers in the course of 20 years. But the quality of the papers, and the insights they present, are what matter – not their frequency, he points out.

This is something he encourages young researchers to keep in mind when carving out their own careers: "In our team we spend time thinking and experimenting, and we publish when we have something significant to say. That only works if you identify areas that are locally important, but also globally applicable. I study the exceptions to learn about things that are common."



| DUNCAN MITCHELL |

TOP THREE AWARDS

- Harry Oppenheimer Fellowship from the Oppenheimer Memorial Trust, 2010
- Receiving an NRF A1-rating in 2007 and again in 2012
- One of four winners of the Outstanding Young South Africans Award, 1980

DEFINING MOMENT

Starting to work with Prof Cyril Wyndham, who led the Human Sciences Laboratory of the Research Organisation of the Chamber of Mines of South Africa.

WHAT PEOPLE DO NOT KNOW

"I started school life in a girl's school" – St Mary's in Johannesburg, which at the time took in a few boys in the entry year.



DELVING IN WHEN THE HEAT IS ON

“Serendipity” and “luck” are mentioned frequently when heat and pain expert, Prof Duncan Mitchell, looks back on defining moments of his life as an A-rated scientist and a conservation physiologist. His spirits are only dampened when the inevitability of climate change becomes the subject. But even then, he has a Plan B in mind.

He was Director of the Brain Function Research Group at the University of Witwatersrand (Wits) between 1988 and 2006 – a research entity whose staff works on matters related to pain, fever, sleep and the influence of heat on humans and wildlife. The career of this Founder Member of the Academy of Science of South Africa (ASSAf) and former President of the Royal Society of South Africa has taken him to 26 countries to lecture on anything from the pain associated with HIV or women’s menstrual cycles to how apes, antelopes and elephants handle heat. He is also regarded as a sage when it comes to thoughts around training medical students and academic administration.

It all started because of his inauspicious studies in physics, and his subsequent unplanned yet very lucky meeting with mining expert and physiologist, Prof Cyril Wyndham.

EARLY YEARS

Mitchell was born on 10 May 1941 in Germiston. At the time, his family was living in Durban, but with his father away in East Africa during World War II, his mother went to stay with her sister. A few years later, his family moved north to Johannesburg, where Mitchell has lived ever since for all but four years.

Studying towards a BSc degree with physics and mathematics at Wits was “purely serendipitous”.

“It wasn’t as if I had an ambition or a career in mind; I was simply good in maths and science and went to do that at the university,” this St John’s College old boy describes how his study choice came about.

By his Honours year in 1964 he had developed a particular interest in biology. It was influenced in part by a certain zoology student, Lily May Austin, who would later become a business coach – and his wife. The couple celebrated 50 years of marriage in 2016.

Then there was also the head of his department, Prof Frank Nabarro, a hugely formative influence. He believed Mitchell would “be useful but never good in physics”.

It was indeed good advice to leave physics behind. Mitchell now counts Africa’s most prestigious research prize, the Oppenheimer Fellowship (2010), among the honours he has received. Already in 1984 he received an A-rating from the Foundation for Research Development, followed by an A1 evaluation by the National Research Foundation in 2007 and 2012.

Back in 1964, however, Mitchell found himself in an administrative quandary. Even though he had a higher degree in biology in mind, it wasn’t easy to switch over to a discipline other than that of his undergraduate degree. Nabarro perhaps unknowingly set Mitchell on his life’s course. “He said I could study postgraduate biology, on condition that I work with the one local biologist he admired: Cyril Wyndham.”

“It was a wonderful, wonderful piece of luck for me; I couldn’t have wished for a better mentor,” underlines Mitchell, who has mentored more than 40 PhD and MSc students and in 2012 received his DSc (honoris causa) from Wits.

Wyndham led the Human Sciences Laboratory of the Research Organisation of the Chamber of Mines of South Africa at Wits. It was mandated by the mining industry to resolve issues surrounding heat-related deaths in South African mines. “We had to keep miners alive,” is the two-second summary of the life-enhancing work Wyndham’s team did.

Many of their recommendations are still followed. They, for instance, found that better cooling is achieved when miners do not have to work in totally stagnant air, and the wind speed over them is increased.

For the next nine years Mitchell delved into the subject with zeal and published the first of his more than 260 scientific papers in 1965.

"I still work on how to keep things alive in the heat, but it's now big mammals, and the heat comes from climate change," explains this Fellow of the Royal Society of South Africa, Honorary Fellow of the Physiology Society of Southern Africa and member of many international scientific bodies and national academic administrative committees and endeavours.

In 1973, the Mitchells and their two young children settled in Harpenden near London so that he could further a new interest in neurophysiology. He had a five-year contract with the UK Medical Research Council at its National Institute for Medical Research.

When budget cuts were making life in England quite difficult, Mitchell seized the opportunity of a lectureship at his *alma mater* in 1975. He became a Professor in physiology a year later. Ever since, Wits has been Mitchell's academic home, well beyond his official retirement in 2006.

RESEARCH ON PAIN

His move to Wits did however transform Mitchell into something of a scientific juggler – all because his keen awareness of the interests of others. His heart was in studies on temperature-related matters and climate change, yet he continued to pursue the pain-related research that he had started in the UK. The nervous pathways detecting pain and temperature are very similar. Mitchell realised it would typically be more interesting to the many students with a health sciences background with whom he often worked. Over the course of the next ten years his research team became world experts in the then poorly researched field of dysmenorrhoea (period pain). They studied how it influenced women's performance during exercise, how it affected their sleep quality and the reasons behind it. Studies into aspects of sleep and exercise subsequently followed.

"The pain research allowed me to respond to South African human needs," he reflects on how his team began switching gear when the AIDS epidemic evolved.

"Almost 60% of people who are HIV positive experience really bad pain," he summarises the situation. Antiretrovirals can in fact make it worse.

One of Mitchell's former PhD students, Prof Peter Kamerman, now leads this work. In 2015, Mitchell published the last of his co-authored papers on the topic. Another PhD student, Prof Andrea Fuller, now heads the Wildlife Conservation Physiology Laboratory.

"The thing I am most proud of in my career is how well the people have done who have been through my hands," says Mitchell. Opportunities such as the Mellon Foundation Retiree Mentor programme have enabled him to be involved with students even after his retirement.

TEMPERATURE-RELATED RESEARCH

Mitchell is passionate about his ongoing work and those who work alongside him. He is a man with a keen ear, an interest in the world around him and in how it works. Birding, badminton and watching ballet count among his many interests, and there's nothing better for him than to wake up on the family reserve to the sound of a bulbul.

His successes with his protégés notwithstanding, Mitchell believes his biggest contribution to science has been finding ways to take physiological measurements of free-ranging animals. These include the use of implanted data loggers and radio telemetry to monitor the vital statistics of animals living in extreme temperatures and aridity, while still allowing them to lead their natural lives without humans being near.

This work has allowed him to apply everything he's learnt about physiology over the years in a climate change context.

In the process he has done much to advance the field of conservation physiology – one which notes how animals and plants are adapting to climate change, and considers how people should deal with it. He was among others, part of the very first team to measure the body temperatures of free-ranging non-human primates – that of baboons and vervet monkeys.

ONTO DATA LOGGING

Mitchell's wildlife research career started in the late 1970s with studies about the heat response of rabbits and giraffe, and how insects and reptiles in the Namib Desert coped. In the process he developed an overarching and very productive interest in comparative or conservation physiology.

Again, the word "luck" is used to describe how his numerous desert encounters with American Dr Mary Seely of the Gobabeb Research and Training Centre in Namibia came about.

In the early 1980s he and the late Prof Helen Laburn studied animals' reaction to fever, and wanted to look at local lizards with very high body temperatures. A referral to Seely set about a productive working relationship of three decades.

Encouraged by the late and legendary physiologist Prof Gideon Louw of the University of Cape Town, they first used small radiotelemetric methods to monitor Namib lizards. Since the research was transferred to large mammals, implanted data loggers have been used to record the vital statistics of armadillo, pangolin, cheetah or zebra for up to a year before being removed for analysis.

The idea that one could use commercial data loggers came from Prof Rudi van Aarde of the University of Pretoria, who measured forest floor temperatures with reasonably inexpensive equipment from the USA. In the States, the technology was used to track the temperature of fruit being trucked cross-country, and its manufacturers actually strongly discouraged their use in animals. Thanks partly to the efforts of the Wits team, since the 1990s these devices have shrunk to the size of a Myprodol capsule.

The team had been measuring body temperatures of free-ranging mammals for ten years before they realised how important the data could be to conservation biology. An important influence was a definitive paper authored, amongst others, by Prof Barend Erasmus, now Director of Wits' Global Change and Sustainability Research Institute. It predicted that because of climate change, the Kruger Park could lose 60% of its mammal species.

"There was growing evidence that climate change would be a really big problem for big mammals, because they live too long to adapt genetically," Mitchell summarises the paper.

Part of his Oppenheimer Fellowship has since gone into developing further data logging techniques appropriate for big mammals such as elephants, antelope, primates and camels. Because Mitchell is also concerned with the future of livestock, he works in the Karoo with Prof Graham Kerley of Nelson Mandela Metropolitan University on how Angora goats cope with heat and cold.

"Climate change is happening and there's nothing we can do about it, even if all the governments in the world do everything they promise to do," he states emphatically. "We might as well stop worrying about measures to alleviate it within the next 30 years, and rather concentrate more on how to adapt to it. What we have to do to make sure that animals survive, and that we survive in what is now inevitable."

With luck – and through the people who are following in Mitchell's footsteps – science might just be able to find the answers.

| VALERIE MIZRAHI |

TOP THREE AWARDS

- Christophe Mérieux Prize, Christophe and Rodolphe Mérieux Foundation and Institut de France, 2013
- National Order of Mapungubwe (Silver), 2007
- UNESCO-L'Oréal Award for Women in Science (Africa & Arab States Region), 2000

DEFINING MOMENT

The most fulfilling moments of the last decade for me were my daughters' graduations. Nothing that I've done professionally gets close to that – not the papers I've published nor the awards I've received.

WHAT PEOPLE DO NOT KNOW

When I got appointed to lead the Institute of Infectious Disease and Molecular Medicine at UCT, I had limited business administration skills. I was going to take a course in financial management at Wits, but I ran out of time. So before coming to Cape Town, I spent a weekend with my father learning how to read a balance sheet.



THE SHAPE-SHIFTER

Professor Valerie Mizrahi isn't sure where her home really is. She was born and raised in Zimbabwe, and studied in South Africa. She spent the lion's share of her active research career at the University of the Witwatersrand (Wits) in Johannesburg, but since 2011, she has led the Institute of Infectious Disease and Molecular Medicine at the University of Cape Town (UCT). Her passport says she is Italian, but she has never lived in that country.

"I don't really know what I can call 'home'. I know from a country point of view I'm absolutely South African. But I'm not sure that Cape Town is my home. The energy and the people of Joburg remind me more of Harare, where I grew up. I'm not sure that I'm fully accepted as a South African. I speak English a little differently from the locals, and my knowledge of Afrikaans, isiXhosa and isiZulu is rudimentary," she says.

She is happier identifying herself simply as a scientist. But even in this most permanent aspect of life she has shifted shapes many times. "I've walked an interesting path, from chemistry to biochemistry, genetics and microbiology. Scientifically, I'm a tuberculosis researcher, and my calling is that of a basic scientist. But now I'm leading an institute of infectious disease and molecular medicine, and I don't have a clinical background."

Walking the path has taken guts, or as Mizrahi with her Jewish ancestry might call it, "chutzpah". Fiercely independent, she forged her own way in research, becoming one of the first South African scientists to tackle the growing threat of tuberculosis at the level of basic science. She has played a leading role in the fight against the scourge, which fuelled by HIV and drug resistance, has emerged as one of the biggest current threats to global health.

EARLY LIFE AND EDUCATION

Mizrahi was born in Harare in modern day Zimbabwe in 1958. Her grandparents had fled Europe before the war, and her father was a chemical engineer trained at the University of Cape Town. She went to a school for privileged girls, where she discovered a fondness and aptitude for the

natural sciences. It was a natural choice to study something scientific after her A-levels.

She considered going to university in the UK or Israel. But during her last year of A-levels she fell gravely ill. She wrote her finals in hospital and realised that going overseas might be problematic. South Africa was much closer, and so she ended up studying chemistry and mathematics at UCT. She followed up her undergraduate degree (awarded with distinction) with an Honours degree and a PhD in chemistry, both at UCT. The lack of women in the faculty didn't deter her interest in becoming an academic herself. She didn't even notice it, she says, and she felt that the male professors treated her just like everyone else. What did bother her, however, was the racial segregation in South Africa. Her time as a student at UCT included a political awakening, and by the time she was a postgraduate she was angry about the *status quo* in the country, and like many of her classmates and friends, she wanted to get away.

From 1983 to 1986 she found work as a postdoctoral fellow at Pennsylvania State University in the USA. The postdoc wasn't in chemistry, but in biology. The change of subjects didn't faze Mizrahi, even though she hadn't even studied biology at school. "I had a certain recklessness and adventurous spirit, and at that time there was nothing wrong with changing your field," she says. It was tough being up against Ivy League graduates, she admits, but after six months she had found her stride.

After her postdoc she returned to South Africa for a spell, working for the Council for Scientific and Industrial Research in Johannesburg. Then once more she went abroad, this time to work at the drug company, SmithKline & French's R&D hub in Philadelphia. However, this time she hit a glitch: her husband, Basil Sher, couldn't get a visa to join her. After spending a year away from home, she decided to return to Johannesburg. Also, she knew she wanted children, and she wanted her children to grow up close to their grandparents, who by that time had also moved to South Africa.

RESEARCH AT WITS

Mizrahi returned to South Africa in 1989, where she took up a position at the South African Institute for Medical Research (SAIMR), an institute with

close links to Wits, where she established the Molecular Biology Unit. Her only question was what would she work on with her team?

In the US she had worked on HIV drug discovery, but she could not easily see how to remain competitive in this field from South Africa. From her position in the SAIMR, she recognised that tuberculosis (TB) was this lurking problem in South Africa that not many people were talking about. Yet it was there, in the mines and in the hospitals. She started reading about the bacterium that causes the disease, and became fascinated by it. It seemed a worthy foe.

Mizrahi went to visit Paul van Helden at Stellenbosch University and the late Lafras Steyn at UCT, who were among the few South Africans working on TB at the time. They were using molecular diagnostic technologies and genetic analysis to study the TB epidemic in the country. But that wasn't what Mizrahi wanted to do. A basic scientist to the core, she wanted to understand the bacterium itself. As TB became a bigger research focus worldwide, her unit was in a great place to benefit.

However, it wasn't all plain sailing. In the early 1990s, she wrote an application to the Wellcome Trust for the very first round of the UK charity's senior fellowship scheme for South Africa. Her proposal on TB made it to the final round, which involved going to London for a face-to-face interview. Seven months pregnant with her second child, Mizrahi flew to London. But the interview committee savaged her. In hindsight, she thinks this was partly because her proposal wasn't good enough, but also because she had decided to move fields.

She didn't get the fellowship, and returned to South Africa with her tail between her legs. But the experience taught her a valuable lesson: failure is not the end. "It was a fantastic learning experience for me because I went back to the drawing board, thought more deeply about the questions I wanted to address, and soon, the funding began to flow." She began working on drug discovery, and managed to get international funding to build the institute's first biosafety level 3 lab, which led to even more opportunities opening up.

As one of their key research questions, Mizrahi and her team tried to understand how the tuberculosis bug could persist in an infected individual for decades before reactivating to cause disease. "I wanted to understand the survival and subversion tactics of this formidable human pathogen," she says. A team led by Stewart Cole, then at the Pasteur Institute in Paris, was sequencing the genome of the bacterium at the time, and her lab was ready to start working on analysing the sequencing data as they became available.

The highlights of this work were published in an article titled DNA Repair in Mycobacterium Tuberculosis: What have We Learned from the Genome Sequence? in 1998 in the eminent journal *Molecular Microbiology*. It was one of the first papers to follow on from the *Nature* paper publishing the TB genome sequence, and it had come out of a small, relatively under-resourced lab in South Africa.

"It was one of my best papers," Mizrahi says, proudly. "It was just such fun. I was unfazed by the fact that we were dealing with inadequate tools. We made an exciting discovery that set the stage for a lot of work, not only for my own lab, but internationally." The work had a link to TB drug resistance – a growing threat worldwide – since understanding how the TB bug fights its host's defence mechanisms on a molecular level, which is also where mutations causing resistance arise.

Over time Mizrahi's research team and influence grew as many accolades testify

MOVE TO CAPE TOWN

Mizrahi could easily have remained at Wits until her retirement as the queen of her fiefdom with a string of accolades to her name. But resting on her laurels is simply not her style. From 2008, Mizrahi served as the Chair of the international scientific committee of UCT's Institute of Infectious Disease and Molecular Medicine (IDM). She had followed the institute's growth over the years, and was impressed by the way it brought people from across the basic, clinical and public health sciences together, in one place.

When the Director of the institute, Greg Hussey, decided to step down, he approached Mizrahi to see if she would consider applying for the position. She thought about it. She had just gone through a divorce, and her one daughter was about to study at UCT. "Wits and the National Health Laboratory Service had provided the environment for me to become the scholar I am today, but change is good. What was I going to do for the next 15 years of my life?" And so, she says, the "same madness" that had driven her to go overseas in her early 20s once more took root.

She agreed to travel to Cape Town for an interview. When she told her colleagues at Wits about it, she couldn't shake the feeling that she was betraying them. Nevertheless, when she was offered the job she took it, and with the support of her colleagues at Wits, she set off on a new adventure. The job at UCT was overwhelming, to say the least. The IDM is the largest postgraduate research entity at the university, with more than 500 faculty, staff and students. Its researchers raise R350 million in grants in a year.

Not coming from a clinical research background, Mizrahi was suddenly in charge of a large research enterprise with a major clinical component. She had a lot to learn, including the specific challenges of clinical and community-based research. However, her biggest challenge was learning how to delegate. At Wits she had effectively been her own boss, and as head of a smaller unit she could influence the culture by imposing her values in a way that is far more difficult to do in a large, multidisciplinary institute.

"My first year was a baptism of fire. I had never been comfortable asking others for help. So I went for professional coaching. UCT has a fantastic system in house for supporting senior leadership through coaching," she says. Another sacrifice she had to make in her post was being at the very forefront of her own field of research. Having stepped up to a leadership role with major administrative and managerial responsibilities, she feels that her own research has taken a bit of a knock. "I expected it would happen," she says. But, she is enormously proud of the way in which some of her former trainees are now leading certain research programmes which she had initiated.

She tries to be sanguine about losing some of her cutting-edge expertise in her field. She reasons that perhaps it is just part of moving into a more senior role. "Is that not what leadership is? Making space for great young people to exercise the privileges that I had when I was younger."

She doesn't know how long she will stay in the post, but she doesn't think she will retire as the Director of IDM. "I do think leaders need to step down after ten years at the helm," she says. As for where she will go and what she will do, she isn't sure. Her one daughter is studying in Canada, her other daughter remains in Cape Town. She enjoys a slightly better work-life balance in Cape Town than she did in her earlier years as an academic. "I see movies, walk on the beachfront, I go to spend the Jewish holidays in Joburg with my family."

Looking back, she is pleased with her choices. In South Africa, she has had more flexibility and freedom to follow her heart. She feels that her relative impact has been greater here than it might have been abroad. "I've been an 'academic entrepreneur' here. I've been given opportunities and have taken them," she says. She uses her international influence to send bright young students overseas to get the sort of training and exposure that she got when she was their age. By mentoring young academics, she feels that she is having an impact on the future. "I think I have shifted some shapes here," she says with a smile.

| PHUTI NGOEPE |

TOP THREE AWARDS

- National Order of Mapungubwe, 2008
- NRF Presidential Transformation of the Science Cohort Award, 2008
- The prizes his students have received at conferences

DEFINING MOMENT

When his father intervened to send him 250 km away from home to a school where he could study mathematics and science.

WHAT PEOPLE DO NOT KNOW

Every member of his immediate family holds a PhD. His wife Junia holds a PhD in English from North-West University, son Noko a PhD in chemical engineering from the University of Cape Town and daughter Malebogo, a PhD in mechanical engineering from the University of Oxford.



A DIPLOMAT OF NOTE

When Prof Phuti Ngoepe was a first-year BSc physics student in 1972, it was still the very early days of supercomputers and computational number-crunching in a big way. The personal computer had not yet been invented, and there was only one large calculator available in the Department of Physics that only his professors at the then University of the North (now University of Limpopo) could use.

Today, the University of Limpopo is home to the Materials Modelling Centre, of which Ngoepe has been the dedicated Director since its inception in 1996.

Over the past three decades, this passionate researcher has become a leader in computational modelling in South Africa, a regular speaker on the topic around the world and a much-loved mentor of students. He has guided new initiatives, helped shape science policy and cement South Africa's international research relationships.

In 2007, the centre's efforts were strengthened considerably. Ngoepe was awarded a research chair on computational modelling of materials as part of the then new South African Research Chair Initiative (SARChI) of the Department of Science and Technology (DST) and the National Research Foundation (NRF).

"The SARChI Chair has provided us with an excellent opportunity to extend computational modelling into high-performance computing at the University of Limpopo," he acknowledges. "It has been enabled by the establishment of the Centre for High Performance Computing in Cape Town, and has made South Africa competitive."

RESEARCH ENDEAVOURS

Ngoepe, his colleagues and postgraduate students use so-called third-emerging scientific methods of computational modelling to develop computing methods and models. These are used to predict properties of minerals, light and precious metal alloys, and energy storage materials used mostly in lithium-ion batteries.

Research about high-energy density batteries has become increasingly important in the development of electric vehicles, solar energy storage and to support the electricity grid. Better performance and better storage capacity of such batteries are crucial. It can, in part, be provided by materials on the nanoscale, for instance, through nanoparticle, nanorod, nanosheet, nanoporous structured electrodes.

Ngoepe's team has contributed novel work on the simulated synthesis of nanostructures for lithium-ion and newer lithium-air batteries to these efforts. It is used to predict the performance of such structures, by calculating their voltage profiles, microstructures and mechanical properties. These computerised models make it possible to estimate the lifetimes of related batteries before their design is executed practically.

In this, the Materials Modelling Centre participates in the DST's National Energy Storage Programme. It also networks internationally with American national laboratories and through meetings of the International Battery Association.

These are among the many collaborations Ngoepe has fostered over the years, among others through the centre's membership of international software development consortia. Notably he has also worked with several researchers from the United Kingdom through the support of the NRF and the Royal Society, London. Other links are in the European Union and Japan.

The centre's focus on modelling minerals such as platinum and manganese is a logical extension to the University of Limpopo's close proximity to some of South Africa's most valuable mining areas.

Together with South African mining companies and other research institutions the centre looks at efficient mineral processing approaches that address challenges of water, energy and environmental conservation.

"These are becoming imperative in the mining sector," explains Ngoepe, who guides his students to study minerals and mineral surfaces properties through quantum mechanical, semi-empirical and empirical methods. Large-scale simulations are conducted thanks to the empirical potential

models of mineral sulphides in platinum ores they have derived and validated. This has ushered in accurate studies of the surface properties of large systems, including nanoparticles.

The centre also works on the phase stabilities of precious and light metal alloys, and in particular their thermodynamic, elastic and vibrational properties and related high-temperature studies.

"The approach has provided valuable information for aerospace applications, shape memory devices and powder metallurgy processing," Ngoepe elaborates on the work that is part of the DST's effort to benefit titanium and precious metals.

EARLY YEARS

It wasn't easy to set up and run a research-driven centre at an institution with a historical disadvantage in terms of resources and funding. Through determination and a belief in especially the abilities of his students, colleagues and collaborators, Ngoepe has made it work.

No wonder that of him has been said: "He was born for a big purpose and turned an academic desert into a paradise. He is a serial promoter, researcher, and academic traveller".

Ngoepe was born on 7 January 1953 in Polokwane, and matriculated from Setotolwane High School in 1971. His career choice was influenced by his father, an English teacher and headmaster, who often told him about groundbreaking black South African scientists.

In Ngoepe's first year, Prof Bob Seretlo of the University of Fort Hare became the first black person in South Africa to receive a PhD in physics.

"That really motivated me and made me realise what is possible," Ngoepe reflects.

After receiving his BSc and BSc Hons (physics) from the University of the North, Ngoepe considered studying engineering. However, he was offered

a junior lecturing position at his *alma mater* in 1977 – his academic home ever since. In 1981, he received the MSc (physics) with distinction from the University of South Africa, and in 1988 the PhD (physics) from the University of the Witwatersrand (Wits).

Ngoepe, who became Professor in 1992 and a Senior Professor in 2006, counts serving as Dean of the then Faculty of Mathematics and Natural Sciences and as Acting Deputy Vice-Chancellor Academic among the leadership roles he fulfilled at his institution.

UNITED KINGDOM COLLABORATION

A conference in Spain in 1986 changed his life's course from experimental physics to computational modelling.

At the time, he was completing his PhD research under the guidance of Prof Darrell Comins at Wits, and was one of the first researchers in the country working in the field of experimental Brillouin scattering techniques. A vast amount of data churning was needed to really get to grips with his results, but such facilities were not yet available in South Africa.

At the Europhysical Conference on Defects in Insulating Crystals in Madrid, Ngoepe met Prof Richard Catlow, now a Fellow of the Royal Society based at the University College London in the UK. In the 1980s, Catlow was already renowned for his computational modelling work.

When Ngoepe was a British Council Visiting Research Fellow in 1988 and 1989, he visited Catlow at the University of Keele to learn more about computer simulation techniques. He subsequently also spent three months at the University of Bath for ultrasonic studies on condensed matter. A shorter stay at the University of Pennsylvania in the US extended his computational modelling experience and helped him get to grips with non-linear optic techniques.

Since that first Spanish conference Ngoepe and Catlow have become colleagues and collaborators who have provided many of their respective students with shared learning experiences in South Africa and England.

Their combined efforts included a series of materials modelling conferences hosted jointly by the University of Limpopo between 1997 and 2008.

"It helped to promote the awareness of this new field in South Africa," Ngoepe elaborates on their working relationship of more than 27 years, made possible through support by the NRF and The Royal Society, London.

SHAPING STUDENTS

Of his involvement in shaping students' lives over the past 40 years, Ngoepe says philosophically: "There are moments of shared sorrow, when computational data of researchers disappear or experiments break down, but there are so many moments of joy on making new discoveries and when researchers go to conferences and win prizes."

His influence stretches further than just his own students. In the early 1990s, Ngoepe was a driving force behind his institution's Science Teacher In-Service (UNIST) diploma and Science Foundation Year (UNIFY) bridging programme for first-year students who struggled with mathematics and science.

IN SERVICE OF SCIENCE

This great believer in the sharing of ideas and networking has helped arrange many workshops, summer schools and conferences related to the computational modelling of materials. In 2000, for instance, he co-chaired the International Conference on Defects in Insulating Materials in South Africa and still serves on its advisory committee. In 2011, Ngoepe helped with an International Battery Association Conference in South Africa and subsequently co-chaired workshops on energy storage with international partners.

As Chair of the Council for Geosciences – a position he has held since 2003 – he supports the organising of the 2016 International Geology Conference.

He has served on the governing boards of entities such as Mintek, the National Research Foundation, the South African Minerals to Metals Research

Institute, the South African Power Utility Research Advisory Board and the Council of the South African Institute of Physics. As part of its science advisory council he was also involved in the formative years of the CSIR's Centre for High Performance Computing. Ngoepe is a Founder Member of the Academy of Science of South Africa and was a CSIR Fellow.

Despite so many leadership positions, this diplomat of note has never had the inclination to go into politics or government, no matter how hard others have tried to persuade him to leave academia behind.

"I'm just too passionate about research," is his reasoning.

Ngoepe has met them halfway through his involvement in the politics of science. He served on the African National Congress Science Policy Foundation Task Force set up between 1993 and 1994. Since then he has helped develop national science green and white papers, national foresight exercises, as well as strategies looking into establishment of nanotechnology, energy, South Africa's hydrogen economy, advanced metals and mineral processing research and innovation. He also helped review government initiatives such as the National Advisory Council on Innovation and the DST Ministerial Review Committee on Innovation. He is currently involved in coordinating projects about the beneficiation of certain South African minerals to products in energy storage. Participation in bilateral science and technology missions have taken Ngoepe to among others the USA, Russia, Japan, China and countries in the European Union.

Ngoepe has seized the opportunities that have come his way, and has worked hard in the process. The support of his family has been invaluable in this regard.

In 2013, a conference was held to celebrate his 60th birthday. At the time, Dr Reuel Khoza, Chancellor of the University of Limpopo, summed up Ngoepe's career as such: "Phuti's odyssey through the territory of mathematics, materials science and physics has been a delightful cruise characterised by regular distinctions and awards. Phuti's accomplishments as a professional and practitioner in physics and technological innovation, fundamentally redefined such descriptive concepts as dedication, diligence and discipline, putting them unquestionably in the superlative".

| WISEMAN NKUHLU |

TOP THREE AWARDS

- The *Ordre National de la Légion D'Honneur, République Française*, 2005
- The Grand Counsellor of the Baobab National Award, 2008
- Honorary Doctorates from the Universities of the Free State, Stellenbosch, Cape Town, Pretoria, Nelson Mandela Metropolitan, Witwatersrand and Fort Hare

DEFINING MOMENT

When his father intervened to send him 250 km away from home to a school where he could study mathematics and science.

WHAT PEOPLE DO NOT KNOW

... is that he'd love to work more with his hands, and know more about electronics.



A LIFE OF PURPOSE

If business leader and University of Pretoria Chancellor, Professor Lumkile Wiseman Nkuhlu, could have his way, a much greater chunk of South Africa's annual budget would be allocated to science and technology matters. Schools would become centres of science and villages would award prizes to stimulate scientific thinking. Greater attention would be given to developing rural and township schools into educational havens for South Africa's poorest communities; and teachers would be retrained to ensure a world-class schooling system.

"We are not prioritising matters surrounding science and technology as we should," he reflects on progress over the past two decades. By 'science' Nkuhlu does not only mean the natural, physical or health sciences, but the organising of any body of knowledge such as business, economics or literature.

Nkuhlu's continent-wide take on these matters has been shaped since his youth by an almost obsessive belief that science, technology and innovation will help Africa become a major world force.

"Colonialisation and perceptions of inferiority were fuelled when a big gap opened between Europe and Africa in the field of scientific and technological advancement between the 1500s and the 1900s," explains the man who in 1976 became South Africa's first black chartered accountant (CA), and who has deeply influenced the fields of commerce, education and development since.

"You need science to get long-term benefits and to have the confidence that you will change something," highlights Nkuhlu, who has worked in the development field since his early activist years, and describes himself as a "developmental economist".

He does not take the world around him lightly, but purposefully makes an effort to understand and influence it where possible. He therefore also takes matters such as transformation and policy reform seriously.

IN SERVICE OF NEPAD

Nkuhlu could put many of his ideas and idealisms regarding an African Renaissance into practice when he became the first Chief Executive of the New Partnership for Africa's Development (NEPAD) Secretariat between 2000 and 2005. "These years I will always cherish as the highlight of my career," he says.

He was handpicked for the position after being appointed as economic advisor to former President Thabo Mbeki in 2000.

Nkuhlu still remembers how he never dared go to Mbeki with "half-baked stories or ideas", but had to be well-prepared, well-read and informed to escape a challenge from the President.

The 2012 book *A Decade of NEPAD: Deepening Private Sector and Civil Society Ownership and Partnership* by the Economic Commission for Africa, sums up the Nkuhlu years: "During this early period of NEPAD's existence, the initiative captured the imagination of the developing world and was hailed for the fact that it marked the first time that African states had forged a common initiative to change their relationship with the global community – toward partnership, and most importantly, African-led partnership. By the end of Prof Nkuhlu's tenure, strong roots had been planted with external partners, and the beginning of concerted effort to strengthen and rationalise the continent's regional economic communities had begun."

His involvement in NEPAD led to his presidency of the International Organisation of Employers from 2008 to 2011 in Geneva. He also served on the Global Financial Crisis Advisory Panel that advised on the accounting standards setting implications of the worldwide 2009 financial crisis.

Nkuhlu cites another first that he achieved as a career highlight – being the first Chairman of the Council on Higher Education, between 1998 and 2002. He looks back fondly on this time, although he realises that the outcomes of the Council's first term "did not satisfy everyone" in terms of how it could restructure South Africa's universities and technikons.

EARLY YEARS

In the 2014 biography, *Wiseman Nkuhlu: A Life of Purpose*, author Luvuyo Wotshela tells the following story: “After considering the family legacy, as well as the contemporary challenges facing the family, the parents decided to call their firstborn, Lumkile. When Lumkile’s parents were asked to add a Western name to his traditional name, they decided on the English translation of Lumkile, namely Wiseman. Wiseman Lumkile Nkuhlu is thus, in mathematical terms, Wiseman square! This name encapsulated the wishful catchphrase at the time of his birth: ‘This is a wise child, who would devise strategy to deal with hindrances such as those confronting us’.” He has lived up to his name ever since.

Over the years, he has learnt from people like business icon Dr Sam Motsuenyane of the National African Federated Chamber of Commerce and Industry (Nafcoc) about the value of black entrepreneurship and enterprise. His outlook on African politics and development were shaped by leaders such as Julius Nyerere, Kwame Nkrumah and Thabo Mbeki. These days he is inspired by young people of all walks of life who care about South Africa.

“I value the exchanging of ideas, and learning from the leadership styles of others,” he adds. It was however his father who had the first formative influence on him.

“The length to which he went to give me an education!” he remembers gratefully, “and that on the salary of an agricultural extension officer with only Grade 8!”

Books about European history, Napoleon and the French Revolution jump-started his thoughts about Africa’s own continent-wide transformation, the need for scientific reawakening and the policies needed to bridge the knowledge gap.

“I had a strong belief that Africans, given opportunities, are equal to any other human beings in the world,” he said in his biography.

At the Dutch Reformed Church’ primary school of Arthur Tsengiwe in Cala, he already displayed an aptitude for arithmetic and numbers. He started attending Lovedale College near Alice in 1962 during politically tumultu-

ous times, and aligned with the Pan Africanist Congress (PAC) as well as the African National Congress (ANC). In his matric year in 1963, Nkuhlu and other classmates were expelled during student unrests, and subsequently the 19-year old landed up in prison on Robben Island for sixteen months.

In prison, he decided that he wanted to do something with himself, to be skilled and to prove a political point or two in the process. The ‘how’ was not yet clear, but he did imagine himself as the chief economist of the then Organisation of African Unity (today the African Union, in which NEPAD plays a role).

To fly under the radar of the Eastern Cape security police, he sought a position as clerk at the Lorraine Gold Mine near Allenridge in the Free State. He also pursued his academic ambitions and finished matric part-time through Damelin College with economics, accountancy and mathematics as subjects.

By 1967 he had saved up enough to study at the University of Fort Hare, and in 1970 he earned a BCom degree. A Certificate of Theory in Accounting through the University of Cape Town followed in 1975, and in 1982 an MBA from the New York University.

It is however his qualification as South Africa’s first CA – obtained one month before the June 1976 student uprising – that set the stage for his further endeavours. He pursued this milestone with great care and deliberation.

“I said this must be the challenge that I should conquer; it was almost an obsession,” Nkuhlu acknowledges years after he first served his articles with an Afrikaans Mthatha-based firm, Hoek Wiehahn and Cross. “It was my way of showing how much African talent there is, and that such talent is just as randomly distributed as it is among other races.”

He admits that although it gave him much pleasure when he reached his goal, it was even more so when young people started coming to him for guidance.

“I realised I had a responsibility to fulfil towards others,” he adds about the self-imposed obligation as role model he takes seriously to this day. “Leading by example” became one of the mottos he lives by.

This set in motion a string of events that saw Nkuhlu for more than a decade fulfil the dual roles of practising auditor and lecturer.

He started teaching at the University of Fort Hare, and by 1977 had set up an accounting department at the then University of Transkei. From 1987 to 1991, he also led this tertiary institution as Principal and Vice-Chancellor. In 1978, he not only became Head of the University of Transkei's Department of Accountancy, but also set up his own firm, WL Nkuhlu & Company in Mthatha – the first black-owned auditing firm in South Africa. In 1982, it produced two of the country's first five black CAs. During this decade, he also became involved in the development of black entrepreneurship in the Eastern Cape, under the guidance of Nafcoc's Dr Motsuenyane.

"These experiences taught me what it means to work for others," acknowledges the man whom the *Finweek* credits as the force behind the transformation of South Africa's CA profession. "I've never been able to work only for myself or my family."

"It is humbling to meet younger people who have gone on to have success tell stories about how I have influenced them," notes Nkuhlu, who has since 2004 been the Patron of the Nkuhlu School of Accounting at Fort Hare.

IN THE PUBLIC INTEREST

In 1984, he rejoined his old firm, now Wiehahn & Meyernel, as audit partner, and worked there until 1991, two years after it merged with Price Waterhouse (these days PwC).

His service to the business sector also includes being economic advisor to the National African Federated Chamber of Commerce, President of both the Black Management Forum and the South African Institute of Chartered Accountants, and being an independent non-executive Director at JSE Limited.

"Understanding finances, the management of resources and internalising the values of being an auditor helped me to be a successful manager," reflects Nkuhlu.

He bid professional auditing farewell in the early 1990s to join the Independent Development Trust. As its Chief Executive Officer between 1992 and 1995, he made people-centred development the mantra of the Trust.

In March 1993, the *Christian Science Monitor* described him as "the country's most powerful player on the socioeconomic development scene". This was because Nkuhlu was also Chair of the Development Bank of Southern Africa (DBSA), a position he held until 2000. As the first person to hold both positions simultaneously, and the first black South African to occupy both hot seats, he commuted weekly between Cape Town and Pretoria in a juggling act of responsibilities.

"They are the country's two major development agencies and command access to some \$3 billion in resources," wrote the *Christian Science Monitor's* John Battersby. He added that many of Nkuhlu's colleagues felt he was taking on "a superhuman workload", but that he had a "remarkable ability to deliver".

Tasked by the Minister of Finance he led the team reviewing the DBSA's mandate and core business. Their mission soon changed to reforming, rather than replacing, the development agency, and the team's June 1995 report became the basis for the new DBSA.

In the same interview Nkuhlu said: "I don't care what the political orientation of people is. The only criterion in evaluating a project is whether it makes development sense."

FORGING AHEAD

Nkuhlu has been Chancellor of the University of Pretoria since 2007.

"One needs to read widely to make sure that one stays on top of the subject or current thinking," emphasises Nkuhlu.

"Work hard, be disciplined, but have the humility to understand that you cannot succeed on your own. You need the confidence and support of others," he summarised the principles he still lives by, and purposefully so.

| TEBELLO NYOKONG |

TOP THREE AWARDS

- Lifetime Achievement Award from the National Research Foundation, 2013
- South African Chemical Institute Gold Medal, 2012
- A-rating from the NRF, 2013

DEFINING MOMENT

When she received equipment from the National Laser Centre on a long-term loan to allow her to do key research.

WHAT PEOPLE DO NOT KNOW

She enjoys having fun and a good laugh, and that everything isn't just hard work to her.



SUCCESS IS THE ONLY OPTION

Anything is possible, including succeeding against all odds. In fact, not doing so is simply not worth considering.

Armed with this attitude Tebello Nyokong has tenaciously tackled her career as a leading chemist specialising in nanotechnology and cancer research. She is the Department of Science and Technology – National Research Foundation (DST-NRF) Professor of Medicinal Chemistry and Nanotechnology and Distinguished Professor of Chemistry at Rhodes University's Department of Chemistry, and also Director of the DST/Mintek Nanotechnology Innovation Centre Sensors.

The work of this A-rated researcher has been recognised widely. In 2015, she was also called upon by the Secretary-General of the United Nations, Ban Ki-moon, to serve on his high-level panel to investigate a technology bank for least-developed countries.

It's with a decisiveness that anything is possible through science and nanotechnology in particular, that she keeps on exploring how nanotechnology can help fight cancer and even be used to restore cultural artefacts.

Early on in Nyokong's career, she quite deliberately decided to become a role model to others by working hard – and succeeding.

"Not being successful was never an option," says this eldest of three siblings. "I was representing generations to come. If I had failed, it would not be good for all of us."

Nyokong was born on 20 October 1951 in Lesotho's capital, Maseru. Her South African father worked in the building industry, while her mother from Lesotho was a homemaker.

Her parents held a good education in high regard. In fact, her father, who passed away while she was still studying towards her undergraduate degree, firmly believed it would one day lead to the end of apartheid.

"Don't ever stop," she fondly remembers her father's constant words of support. "He used to say that he doesn't care what I do, but that I had to be more educated than he was, and therefore at least pass Standard 6 (Grade 8)."

"I was brought up with the discipline of hard work," she reminisces about growing up in rural South Africa and Lesotho. As an aside, she adds: "I think the discipline necessary in the school system is no longer there."

Colleagues admire her grit and ability to solve challenging problems. Nyokong has always thrived on challenges, ever since she decided to change her high-school subjects from the arts to the sciences subjects. Some serious catch-up was called for to get to know the new study material in time to matriculate successfully. "The sciences challenged me," she remembers the influence of her change of course. "It was exactly where I had to be."

Years later, she wrote a letter back from the present to her 18-year old self. It highlighted that potential stumbling blocks such as poverty and the expectations of peers and society should never stand in the way of a person's dreams.

"But you are different. You have an independent mind. You believe you can be a wife and a mother and still be a breadwinner and contribute to society. And you will," reads the letter that was first published in 2011 by the American Science Club for Girls.

Teachers were a source of inspiration during those high-school years. The infectious enthusiasm of a young American teacher, a Dr Gray, for instance, persuaded Nyokong to study chemistry. "It wasn't that I knew what I was going to do with chemistry. In fact, I had no idea, no career guidance whatsoever. I just kept doing it, I just enjoyed doing it."

Therefore scholarships to study medicine or dentistry in Russia or Nigeria were passed up in favour of one from the Lesotho government to study chemistry. "People probably thought I was mad," she chuckles like one who has since proved her detractors wrong in more than one way.

In 1977, she received a BSc in chemistry and biology with a concurrent certificate in education from the University of Lesotho. In 1981, she completed the MSc at McMaster University in Ontario, which was followed in 1987 with a PhD in chemistry from the University of Western Ontario. Her postgraduate studies were funded by the Canadian International Development Agency (CIDA). In 1990, she also received a Fulbright Fellowship to conduct postdoctoral research in the Radiation Laboratory of the University of Notre Dame in the United States.

USING DYE TO CURE CANCER

By 2015, she had already published more than 530 scientific papers, and is renowned worldwide for her work to perfect so-called photo-dynamic therapy. It could potentially be an alternative to chemotherapy, without most of the side effects that this cancer treatment holds.

Together with her students and collaborators she makes molecules called phthalocyanines that can target cancer cells. These molecules are the same as the dyes that give the typical blue colour to a pair of jeans. Researchers recognised the possible medical and pharmaceutical value of these molecules after discovering that they shared the same structure as molecules found in blood. The dye molecules are inert and harmless by themselves, but can be activated when exposed to a red laser beam.

The bureaucracy involved in among others running drug tests on humans has torpedoed Nyokong's dream of ever seeing her lab work being translated into real help for cancer patients. However, work on the technique continues, in the hope that a technology transfer company will one day see this take off.

This Adjunct Professor of chemistry at the University of Tromsø in Norway counts scientists from Japan, the UK, Germany, the US, Belgium, Canada, Russia, Switzerland, Romania, China and France among her collaborators. She regularly works with the CSIR's Biophotonics Group, Mintek and local academics from among others the University of Johannesburg (UJ).

Together with a Romanian colleague she recently started dabbling with these techniques to help restore old books and artefacts. So far they have developed an ultrathin layer to cover ancient pages, and in the process preserve them by halting their typical yellow discoloration.

"One never knows, perhaps it could be the saving grace of Timbuktu," is the hope.

Nyokong was introduced to the topic of photo-dynamic therapy while studying in Canada, and still collaborates with colleagues there.

Although she enjoyed the science and work she was exposed to, she describes her Canadian years as "a character-building experience".

"Being in Canada made me, actually," she stresses. It challenged and drained her, more so because she initially had to leave her two young children behind. "Support of an extended family was wonderful, but it doesn't remove the heart of the mother," she said in one of many documentaries about her life. She also experienced first-hand how her continent was "patronised and put down". This has made her fiercely patriotic ever since. In a documentary on South African icons in 2014, she admits with her typical dry wit that she might have been quite something to get used to by the Canadians too. "To see a little black African woman say that, 'Ja, ja, I know chemistry, and I love it,' was to them quite a cultural shock."

Upon returning to the continent, she first lectured at the University of Lesotho. Her passion for research led her to Rhodes University's Department of Chemistry in 1992. Here she, together with others, supported maths and science clubs at local schools, and helped to provide them with laboratory equipment that was no longer used at the university.

At the time not many African academics had yet found their place in local academic institutions, and she initially struggled to be accepted by colleagues outside the lecture theatres as well.

"If I have to give a title to my biography one day, it will be *Living between Two Worlds*," Nyokong admits. "I did not belong to the black or the white community."

Her tenacity paid off. In 1998, she became an Associate Professor of physical-inorganic chemistry, with a full professorship following in 2001 and her research chair in 2007. Now she is a Fellow of the African Academy of Sciences, the Royal Society of Chemistry, The World Academy of Sciences (TWAS), the Royal Society of South Africa, as well as the Academy of Science of South Africa.

A turning point in her career came when she received equipment from the National Laser Centre (NLC) in 2002.

Nyokong still remembers the late evening phone call from an administrator requesting a proposal for equipment by the following morning. Pronto. She burnt the midnight oil and submitted the proposal – and received R3 million worth of equipment on a long-term loan.

“It has since made everything possible,” she recognises.

NEW AFRICAN WOMAN

Nyokong was inducted into Lesotho's Hall of Fame in 2010. In 2006, the *Financial Mail* included her on their list of top-100 influential people in South Africa, and in 2012, she made it onto *IT News Africa's* list of Africa's ten most influential women in science and technology. She's one of 12 people “who

will change the world” according to the National Centre for Research on Human Evolution in Burgos.

This fierce advocate for women scientists knows the difficulties that a career in research can entail. It's therefore recognitions she received based purely on her science, rather than on her gender, that she values most.

As she nears retirement age, it's towards her students that Nyokong focuses her efforts all the more. “I am perhaps sometimes too passionately involved with my students,” comes the admission.

By 2015, 40 PhD students had already come out of her fold, as well as 28 MSc students, 23 postdoctoral fellows and numerous Honours students.

“To have a PhD makes you a leader, and you have to be ready for it,” Nyokong believes. “The country needs leaders, not people who cannot think and are not disciplined.”

That's why she embraces visits to her laboratory by collaborators and dignitaries such as the Minister of Science and Technology or the Public Protector. These visits become opportunities through which she can groom and shape her students into researchers who are able to talk about their work to all and sundry. She holds the ability to communicate science in high regard, and as integral to the making of a successful researcher.

| CLAIRE PENN |

TOP THREE AWARDS

- Winner: Science & Technology Category, Shoprite/Checkers SABC2 Woman of the Year Award, 2008
- National Order of Mapungubwe (Silver), 2007
- Joint winner: Department of Science and Technology Distinguished Woman Scientist award (Academic Excellence in Social Sciences or Humanities), 2010.



DEFINING MOMENT

Working on the South African dictionary of sign language, which introduced Penn to the notion of culture and language, eventually leading to her interest in better communication within health settings, particularly for the marginalised and voiceless.

WHAT PEOPLE DO NOT KNOW

"I had a birthday once where I invited my hiking friends and my academic friends, and they must have thought, 'how can this be the same person?' – I'm leading two separate lives as a hiker and as an academic, Penn has climbed Mount Kenya and has recently taken up botanical art. "Botanical water colours go against my very nature because it takes a week to paint one flower. But my artsy side is coming out now – it's been suppressed my whole academic career." Her sons share her two sides, though individually – one is an artist, the other a scientist.

IT IS IN THE MESSAGE

"When I'm out of Africa for too long I feel terrible," asserts a well-travelled, Kenyan-born hiker, activist, therapist, mentor and mother.

Professor Claire Penn is all these things, and she's the Director of the Health Communication Research Unit at the University of the Witwatersrand (Wits). There, she's carved out a unique groove into which streams from both the 'hard' and 'soft' sciences flow.

To understand Penn's professional groove and mission, imagine you didn't have the confidence to say "no" when it really mattered, or that you could not find the words to convey a life-threatening emergency to a medical professional.

Picture suffering with a complex chronic disease and being expected to follow treatment instructions given to you in your third or fourth language. And consider the effect on the family of a career poet or novelist who suddenly loses the ability to compose the words their livelihoods depend on.

Whether because of stroke, language and cultural barriers, time constraints or deafness, thousands of South Africans are unable to get their message across effectively. This fact is becoming more and more evident, says Penn, whose team of researchers study communication within many different health-related contexts.

Penn's research unit occupies a niche that brings many disciplines within health and the humanities together. She is trained as both a speech therapist and an audiologist. "One has to do with speech and language problems, and the other has to do with ears. I don't think you can separate the two when talking about communication in the South African context – because of our history and the problems we see in the communities we work in, we need people with the skills to do everything those communities require."

SOCIAL ACTIVIST

It's no secret that Penn is a self-proclaimed social activist. This fuels her fervent insistence on a multi-disciplinary approach to research, and a reli-

ance on qualitative methods, which she says is often the only way to study the complexities of health communication.

"What I'm most proud of is that instead of just sitting in some office, I'm actually doing things on the ground, working with people. For instance, I sat under a tree in Uganda teaching young girls how to say 'no' to transactional sex [a relationship in which money or gifts are exchanged for sex]. I love seeing the resources of people and their incredible resilience; both health care workers and patients, and seeing how we can help deploy them to make things better."

With such clarity in her calling today, it is strange to think that in her early years at university, Penn only chose speech pathology and audiology because she wasn't sure which direction she wanted her career to take.

"I saw it as something that would give me a lot of choices. It seemed a frivolous way to make a career decision, but I've always loved maths, biology, English and people," she says. "I used to count verbs and now I'm looking at narratives."

Though she enjoys every aspect of her career today – especially teaching, training communities, and writing – her work is far from merely collecting stories, and not at all fun and games.

Her journey into this niche really began during her PhD, when she studied patients suffering from aphasia, a lifelong condition of language impairment following brain damage.

"There is nothing more special than a person who has aphasia as a result of a severe life event such as stroke or head injury – the ability of these people to adapt and get on with life is incredible. They may have been a poet or a lecturer, but can never again express themselves as they did before."

She still runs an aphasia group at the institute, and treating them remains her first love. "I learn so much more from them than I'll ever be able to teach," says Penn. "These are just remarkable, wonderful people."

Her therapeutic approach is all about adaptation, compensation, attuning to the needs of the environment, and focusing on ideas rather than just words. "I get very cross with other therapists when they say, for example, 'Oh no, we don't do Tswana'. Make a plan! Meet the human being even if you don't have the vocabulary."

This idea of a human connection and an individual approach rather than relying on textbook methods underscores much of Penn's work following her PhD.

For instance, when she was seconded to the Human Sciences Research Council to produce the South African dictionary of sign language around the time South Africa was transitioning into democracy, she discovered colloquialisms as diverse as the country itself.

"The project was this common cohesive force bringing together black and white deaf people; Afrikaans ladies from Pretoria and Zulu people from rural areas came together to celebrate the diversity of sign language, but also to assert the rights and language of deaf people," she says. "It was just a microcosm of what was happening on a broader scale in South Africa."

This experience was one of the first to really introduce Penn to the notion of culture and language. "Working with the deaf taught me that deafness can be a disability with a small 'd', but Deafness is also a culture with a big 'D'."

NEED FOR COMMUNICATION

At the same time, her work as a therapist in the health sector began to make her aware of the need for better communication in a health context; communication that would take individual needs, such as language barriers, cultural differences and disabilities, into account.

"I then started looking at how better health communication could help us deal with the HIV/AIDS epidemic," says Penn. She completed an ethics qualification and has served on the Wits ethics committee for over 20 years, where she's been particularly engaged with language issues around

informed consent. "This involves, for instance, helping those conducting drug trials get the language right so that participants would understand. And we look at how interpreting should take place in the health care sector."

Concerningly, Penn's research has consistently shown that understanding among patients in various health settings is very poor. But because every human being – health care practitioners and patients alike – is an individual, finding a broad solution is incredibly tricky, and, contrary to the textbooks, there is no one-size-fits-all approach.

"What you need to do is go into a site and use research methods that will uncover the specific dynamics of that site." These methods are often qualitative, including conducting interviews, recording interactions and ethnographies (observing people and cultures to understand their point of view).

"It is wrong to say, 'This is how we should explain diabetes to patients', or 'That is how a white doctor should talk to a black patient in a rural clinic'," she says, adding that this approach simply won't work. Penn explains that if a health worker merely asks, "Do you understand Ma?" the patient is likely to say "Yes" because they want to go home, not because they actually grasp the information.

In one study, Penn and her team divided mothers into two groups. "In the first group we took details about their babies in the standard form: 'age!?'; 'when born!?'; 'how big!?' In the second we group we said, 'tell us your story'."

Doctors had initially protested that they didn't have enough time for that approach, but the study showed that it took the same time to collect patient information, and that in fact the most pressing concerns of the mother came out in the foreground. In other words, the patients communicated the reason for their visit to the doctor much more effectively, which simplifies diagnosis and hence treatment.

Penn has received much criticism for her approach to research. For example, although her work falls into the humanities, many insist the research belongs in the health sector. And those in the health sector ask questions such as, "Why did you only interview 15 people, rather than analysing 3 000 responses?"

But Penn believes her unit's methods make a tangible difference in communities, rather than being purely academic. The study she considers most impactful in this regard was conducted by Prof Jennifer Watermeyer during her PhD under Penn seven years ago. Watermeyer, who is an Associate Professor and an NRF-rated researcher like Penn herself, looked at communication in pharmacies in the North-West Province.

"Even though the pharmacists were Afrikaans-speaking, and the patients were Tswana-speaking, this community was able to achieve an excellent level of adherence to antiretroviral (ARV) drugs through a range of strategies," explains Penn. The pharmacists used props, various non-verbal techniques and repetition to convey their messages.

Despite being a single case study, Watermeyer's findings hint at interventions that may be trialled elsewhere and for other diseases like tuberculosis or diabetes. "Single case studies should be published [in peer-reviewed journals], especially if they are outliers," says Penn, in response to further criticism of this approach by academic peers.

"In that study we found fabulous evidence of mutual efforts towards understanding the complicated dosage of ARVs, which at that time depended on factors like whether the patient is ill, pregnant or overweight."

Another study revealed that informal structures within health care settings, such as patient support groups where mothers sit knitting and chatting, yield insights into barriers to care. In work as yet unpublished, Penn and her students aim to extract what works in some of those informal structures and feed it into formal structures.

A further example of how Penn's approach leads to concrete interventions can be found within a particular emergency call centre in the Western Cape that had been experiencing slow response times. When Penn first interviewed staff, the call takers, dispatchers, administrators and ambulance team all pointed the finger at each other as the root of the problem. Penn analysed recorded emergency calls and put the entire staff together in one room to identify communication problems – a simple intervention no one else at the centre had implemented before.

"We found all that was needed was an understanding of each other's communication needs," says Penn. In the end, her interventions improved response times per call by an average of four seconds, "just by changing the way people picked up the phone".

"I got so excited by this result I thought I might resign from Wits to go run the call centre!"

Fortunately for the many other communities she has impacted since, Penn did not resign from Wits, and now regularly conducts training on such 'team communications'.

"I go to Bara and they'll ask me to train the nurses. I say, 'No, everybody must be in one room together – cleaners, nurses, doctors and everyone will learn together how to make things easier for patients'."

She's also conducted training as part of her involvement with the Paediatric Aids Treatment in Africa (PATA) network, and has worked with Drama for Life to communicate with diabetes patients through theatre.

Penn has been told by some that she does too much – too many things, too much diversity. "I work hard, maybe too hard, but I will carry on forever if I can. This is what I really love to do – raising and solving issues."

| MAMOKGETHI PHAKENG |



TOP THREE AWARDS

- Order of the Baobab in Silver: Republic of South Africa, 2016.
- Most Influential Woman in Education and Training (Academic): *CEO Magazine*, 2014
- Most outstanding Senior Black Female Researcher over the last five to ten years: National Science and Technology Forum, 2011

DEFINING MOMENT

Getting her doctorate. Phakeng was amazed by how much more people paid attention to what she had to say. She doesn't believe that a doctorate necessarily makes someone a success, but she does acknowledge that without a doctorate many of the things she has accomplished would have been more difficult.

WHAT PEOPLE DO NOT KNOW

Phakeng is addicted to plain fat-free yogurt. It is her comfort food and she eats about 2kg a week.

MATHS MADE EASY

Mathematics does not always come easy to people. Many a learner has struggled with mathematics in school. Many more have had to learn mathematics in a language that is not their own. For these students, instruction can be obscured by their own fluency in the language of learning and teaching, or by the fluency of their teachers. However, Prof Mamokgethi Phakeng's research has led to a reimagining of how to value multilingualism in a mathematics classroom and how it can be used to facilitate learning and teaching.

Phakeng was born in 1966 in Eastwood (Pretoria) and started school under a tree in 1972 in Marapyane, a rural village in the Mpumalanga province of South Africa. She remembers loving school. "There was never a time when I hated school or dreaded it." Her love for mathematics began in grade 10 during a week-long winter school. "I'm not sure if I was just ready, or if the teacher was that good, but I got hooked." Back at school, her mathematics grades jumped from 60s to 70s and 80s. She obtained a university entrance pass and registered at the University of Bophuthatswana (now part of the North-West University).

When she started at university, she had no idea that mathematics was considered to be a difficult discipline. "At home there was never any conversation about maths being special. My parents never talked about specific subjects, they only talked about being excellent at what you do." For Phakeng, mathematics was just another subject in which she was expected to do well. But from the auditorium full of students in the first year, only a handful of mathematics majors remained by the third year. In the fourth year, she was the only girl in a class of nine.

At the University of Bophuthatswana, BSc and BA degrees included education as a major. Education was taught in tandem with the science and arts degree from the first year through to the fourth year. As part of the education component of the degree, students spent two or three weeks teaching in schools for work experience. Phakeng loved it. "I'm an extrovert, I love talking to people and teaching people." Although she could

have taught other subjects, schools only ever asked her to teach maths. She enjoyed teaching so much that when she finished her BA (Ed) in 1988, she asked for a job as a mathematics lecturer at Hebron College of Education. They were running short of maths lecturers so they took her on. She spent a year there teaching students who were pre-service mathematics teachers.

That year, Phakeng got even more involved in mathematics education. "I was teaching them pure mathematics and mathematics education as well." She was intrigued by the challenges of teaching students mathematics in multilingual and multicultural classrooms. It was the first time she had engaged with what it means to teach mathematics to teachers. "When I did my degree, we did education and mathematics separately. We never did mathematics education." She started reading and thinking a lot about mathematics education, cementing her dedication to the field.

MATHEMATICS AND LANGUAGE

The connection between mathematics and language caught her attention while she was teaching at the college. "The students I was teaching had gone to township schools like I had and they were struggling with English like I had." Language was a challenge for both the teachers and the learners. Phakeng found herself reflecting on how she had coped as a learner in this situation. "Some of the time, I survived by memorising. When I couldn't get the language, memorising was the only thing I could do."

After her BEd in mathematics education in 1993 from Wits (her research project focused on group work in a mathematics classroom of second-language learners), she devoted her research to understanding the language challenges in mathematics classrooms. This was the focus of her research for both her MEd in mathematics education (1996, Wits) and her PhD in mathematics education (2002, Wits).

One aspect of language she studied was code-switching. In multilingual settings, speakers often use more than one language at the same time, alternating among languages within a dialogue, even within a sentence.

[illegible][illegible]

$$\frac{px+q}{((x-a)^2+b^2)^n}$$

$$\Gamma^{(n)}(y) = \int_0^y e^{-t} t^{n-1} dt$$

$$P_2(x_2) = \int P(x_1, x_2) dx_1$$

$$g(x_1, x_2) = \iint g(x_1, x_2) P(x_1, x_2) dx_1 dx_2 = \sum_{x_1} g \cdot P$$

$$P(x) = \int P(x_1, x_2) dx_2$$

$$\sigma_{xy} = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})$$

$$\sigma_{xy} = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})$$

$$\Gamma(y) = \int_0^y e^{-t} t^{y-1} dt$$

$$\sigma_{f(x,y)}^2 = \left(\frac{\partial f}{\partial x} \sigma_x \right)^2 + \left(\frac{\partial f}{\partial y} \sigma_y \right)^2 + 2 \frac{\partial f}{\partial x} \frac{\partial f}{\partial y} \sigma_{xy}$$

$$P(x) = \int P(x_1, x_2) dx_2$$

$$F(0) = \int_0^1 x^{y-1} dx$$

$$P(x=k) = \frac{\binom{A}{k} \binom{B}{n-k}}{\binom{A+B}{n}}$$

$$P(x=k) = \frac{\binom{A+B}{n} \lambda^k e^{-\lambda}}{n!}$$

$$\sigma_x = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2}$$

$$P(e, x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{if } x \geq 0 \end{cases}$$

$$\Gamma^{(n)}(y) = \int_0^y e^{-t} t^{n-1} dt$$

$$\delta(x) = \lim_{n \rightarrow \infty} \frac{1}{n} \sum_{k=1}^n \delta(x - \frac{k}{n})$$

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$$\frac{px+q}{((x-a)^2+b^2)^n}$$

$$\Gamma^{(n)}(y) = \int_0^y e^{-t} t^{n-1} dt$$

$$P_2(x_2) = \int P(x_1, x_2) dx_1$$

$$g(x_1, x_2) = \iint g(x_1, x_2) P(x_1, x_2) dx_1 dx_2 = \sum_{x_1} g \cdot P$$

$$P(x) = \int P(x_1, x_2) dx_2$$

$$\sigma_{xy}$$

$$\Gamma(q) \Gamma(q)$$

$$\Gamma(x) \equiv 1$$

$$\sigma_{xy} = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})$$

$$\sigma_{f(x,y)}^2 = \left(\frac{\partial f}{\partial x} \sigma_x \right)^2 + \left(\frac{\partial f}{\partial y} \sigma_y \right)^2 + 2 \frac{\partial f}{\partial x} \frac{\partial f}{\partial y} \sigma_{xy}$$

$$P(x) = \int P(x_1, x_2) dx_2$$

$$F(0)$$

$$P(x=k) = \frac{\binom{A}{k} \binom{B}{n-k}}{\binom{A+B}{n}}$$

$$P(x=k) = \frac{\binom{A+B}{n} \lambda^x e^{-\lambda}}{n!}$$

$$\Gamma^{(n)}(y)$$

$$\sigma_x = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2}$$

$$\delta(x) = \lim_{n \rightarrow \infty} P_n(x)$$

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Phakeng has noticed a shift in the direction of her research over time. When she began, she thought of language as a benign tool for thinking and communication. However, language choices in a classroom are far more politically charged than she initially believed. Often, the language choices teachers were making had nothing to do with mathematics. "They chose particular tasks because they thought that learners' language proficiency was so limited that if you gave them more complicated tasks, they wouldn't be able to do it."

Other times choices were made to help learners get access to the English language regardless of the mathematical content. There are still teachers who demand that only English should be used in their classrooms in spite of both research and policy that encourages multilingualism. Phakeng found that English was often preferred by teachers, parents and learners because English allowed learners access to social goods even though it impeded the learning process. This revelation of the political aspect of language has led to a subtle shift in the way Phakeng analyses her data. "When I started, my analysis was very much descriptive, describing what is and what teachers are doing. I moved on to why it is that way. When I understood what is and why it is, I moved on to how we resolve this."

Phakeng's research has contributed to creating a new normal. The use of learners' home languages is now encouraged in multilingual mathematics classrooms in order to foster understanding. This is what makes Phakeng's research so important. By studying and showing how multilingualism can be productive, she has been able to develop a mathematics pedagogy and communicate these improved teaching methods to teachers and learners.

Phakeng has been recognised as a B2-rated scientist and has generated over 60 scholarly publications and presentations which have resulted in over 1 000 citations. She has successfully supervised four doctoral and 12 Masters students, many of whom now hold scholarly positions in South Africa or abroad. The tremendous value of her research has been recognised by the institutions in which she has worked. She entered Wits as a lecturer in mathematics education in 1999 and rose quickly to Associate Professor by 2004. She left Wits at the end of 2007 to become a full Professor in math-

ematics education at the University of South Africa (Unisa). Her roles at Unisa shifted from Executive Dean in the College of Science, Engineering and Technology (January 2008 to June 2011) to Vice-Principal in Research and Innovation (July 2011 to June 2016).

COMMUNITY INVOLVEMENT

While Phakeng sees opportunities to engage with the international community as an enjoyable luxury of academia, she remains deeply involved in her local community. She has run empowerment programmes for women in the rural villages of Matamanyane and Lenyenye in the Limpopo province and continues to conduct in-service training for mathematics teachers in townships and rural areas. She is the founder of Adopt-a-Learner Foundation which provides financial and academic support to black learners from townships and rural areas to access and succeed in higher education.

An integral part of her service to the community is her outstanding social media presence. Phakeng sees social media as a way to inspire young minds and challenge them to pursue bigger, better dreams. "Images of success can be misleading for young people. We need to say: this is what real life is. Not to make it sound impossible, but to make it real." She uses social media to share what success really entails, such as how early she wakes up and how much time she spends at the office. She also shares what bothers her, what she's thinking about and what advice she has for success. Advice she often gives is: "Be who you are, don't take nonsense, work hard, don't apologise for being fabulous, and stay the course".

In July 2016, she took up the position of Deputy Vice-Chancellor for Research and Internationalisation at UCT. In her new position, Phakeng will work to ensure UCT's international standing while at the same time encourage it to be a truly African university. "Having someone like me there is not only going to change me, it is also going to change the institution. The context will be shaped by my presence as much as the context will shape me." She expects a lot of learning and growth on both sides. She doesn't think it will be easy, but she is looking forward to this new chapter.

| NYAMEKO BARNEY PITYANA |



TOP THREE AWARDS

- The Order of the Grand Counsellor of the Baobab (Silver), 2006
- Honorary degrees and fellowships from institutions including the Commonwealth of Learning, King's College London, Athabasca University in Canada and Rhodes University
- Honourable mention in the UNESCO Prize for Human Rights Education, 2002

DEFINING MOMENT

When he was not granted a passport to study at Durham University.

WHAT PEOPLE DO NOT KNOW

He loves to travel, and especially to discover new parts of South Africa.

IN PURSUIT OF JUSTICE

The certificate acknowledging his admission as an attorney has pride of place in the office of Prof Nyameko Barney Pityana, former Unisa Vice-Chancellor, former Human Rights Commission Head, Co-founder of the South African Students' Organisation (SASO) and Anglican priest.

He received it 18 years after his plans to apply for admission were thwarted by the banning orders he received in 1978 because of his political activities.

Pityana was therefore quite touched when the then Deputy Judge President of the Cape High Court, JJ Fagan, stood him up in court on 2 February 1996 before authorising that his name be enrolled in the register of attorneys: "Fagan said that a lot of injustice was done against me, but that he hoped that in a small way, my admission to practise law would provide some justice. He did not have to say that."

"An interest in politics and the challenge of law has always been one and the same for me," says the man whose life took many turns before he could officially practise law. This included being a leader in the Black Consciousness Movement and the African National Congress (ANC) Youth League, going into exile and studying theology and philosophy in the United Kingdom (UK) and serving the World Council of Churches.

FORMATIVE YEARS

Pityana was born on 7 August 1945 in Uitenhage. Pityana started school in Uitenhage and attended the Lovedale Institution's secondary boys' boarding school thanks to an Andrew Smith Bursary. He developed into a politically conscious young man who as a 15-year old joined the ANC Youth League.

During his Form 4 year in 1963, Pityana and many other learners were expelled from the school near Alice. By then he had already met classmate Bantu Stephen Biko. Their strong and compelling bond of friendship and comradeship was to lead to the establishment of SASO and their championing of the Black Consciousness philosophy.

Schooling after Lovedale was not easy. At Newell High School in New Brighton in Port Elizabeth, Pityana and others struggled without qualified mathematics and science teachers. When a poor result in these subjects after his 1964 matric exams put paid to any ambition to study medicine, he resolved to study BA (Law) at the University of Fort Hare in 1966. He was to major in law, English and political science.

Pityana reads anything from the classics, biographies, novels to philosophy. Such was his interest in English literature as an undergraduate that a lecturer almost swayed him to consider advanced studies in English literature.

Then came the student unrests of 1968, and Pityana as member of the then banned ANC Youth League and many of his peers were expelled. He subsequently received an opportunity to pursue his studies at Durham University in the UK – but was refused a passport. This decision by the powers that be was a definitive turning point in Pityana's life.

"My studies effectively came to an end, and I committed my life to the Struggle. One can only wonder what would have happened if I did receive that passport," he muses.

In 1970, he succeeded Biko as SASO President, and later served as Secretary-General based in Durban. He coined the slogan "Black man, you are on your own!" that became a rallying cry of students and activists in the 1970s.

Together with various black and white student activists he was banned in 1973 and restricted to Port Elizabeth. He was closely monitored by the security police, detained and tortured and spent much time in prison – at one time a full year.

The banning orders had one positive spin-off: he resumed his studies. In 1974, Pityana enrolled as a candidate attorney at the firm of D Kondile and Somyalo in Port Elizabeth and by 1976 he had completed the BA (Law) and the BProc degrees through Unisa. He however never had the opportunity to apply for subsequent admission.

After Pityana was released from detention without trial between August 1977 and August 1978, he was served with a renewal of a banning order.

"It stated that I could not be admitted as an attorney, practise as such, be on the premises of a law firm or even attend court except as an accused or a litigant," he remembers.

According to legal advice the order could not be challenged. "I was declared a communist and not fit and proper to practise law by the Minister of Justice, PC Pelser," comes the grim memory.

The final straw was a huge confrontation at the security police headquarters at Sanlam House in Port Elizabeth shortly after his release from jail: "I walked out of that place and just knew that I was out of here [South Africa]."

INTO EXILE

Pityana, his wife Dimza and his then 7-year old daughter, Loyiso, fled to Lesotho. As Bishop Desmond Tutu had organised a scholarship at King's College London, the family then further escaped from Lesotho together with student activist Peter Bruce on an aeroplane that the journalist's family chartered.

An intellectual curiosity about religion and apartheid led him to the study of theology and philosophy. It was only in his final year that Pityana decided to offer himself for ordination as a priest in the Church of England. He was trained at the Anglican theological seminary, Ripon College Cuddesdon in Oxford. Ordination and curacy in Milton Keynes followed. He also served as vicar of Immanuel Church at Highters Heath in Birmingham. In 1988, he was recruited to the World Council of Churches in Geneva as Director of the Programme to Combat Racism. "I was drawn more directly to many of the causes for social justice that I was passionate about," he reflects on his family's move to Switzerland at a critical time in the apartheid struggle. "I enthusiastically accepted it, because I realised that it was a much more direct way of being involved in South Africa than just being a parish priest."

BACK TO SOUTH AFRICA

When he was asked by the General Secretary of the South African Council for Churches, Reverend Frank Chikane, to serve as co-convenor of the his-

toric November 1990 Rustenburg National Conference of Church Leaders, Pityana for the first time could step on South African soil again.

During this three months' stay Pityana realised he did not understand the country he had left, or even many of the people he thought he knew. On the positive side, he discovered many others who previously had not been part of his sphere of reference. He found many like-minded people among the Baptists, Pentecostal and Dutch Reformed ministers with whom he came into contact.

"They were all also exercised with the same questions that we had," he says.

The three months gave him time to reflect on a role for himself in his motherland.

"I realised the reasons why we had left did not prevail any more, and that I did not have any moral reason to remain overseas. I also realised that if I chose to stay, I would have no moral right to speak on the South African situation ever again," says this active voice about the direction that the country is currently taking.

In 1993, theologian-activist Prof John de Gruchy invited him to take up an academic position as senior lecturer and senior research officer at the University of Cape Town's Centre for Christian Studies in the Department of Religious Studies. It allowed him to complete his PhD in Religious Studies in 1995 with a thesis titled *Beyond Transition: The Evolution of Theological Method in South Africa – A Cultural Approach*.

That same year, Parliament elected him to the inaugural Human Rights Commission (HRC), which together with the Office of the Public Protector were among the first Chapter 9 state institutions established to strengthen constitutional democracy.

"By and large my law background came into play for the first time since I had finished my degree many years before," says Pityana, who was elected as HRC Chair at its first meeting.

From 1997 to 2003, Pityana served as a member of the African Commission on Human and Peoples' Rights. He also contributed to the United Nations

human rights and development programmes as an expert and consultant. He still feels privileged to have been part of the formative yet often tumultuous first years of the HRC. "In fact, it would have been heart-wrenching for me had I not been part of such exciting times," says this strong believer in the need for the Commission to be an independent institution.

His job as Chair gave him the opportunity to work closely with former President Nelson Mandela at a time when it felt to Pityana "as if the country was coming together".

Nine often tumultuous years as Principal and Vice-Chancellor of Unisa followed. His mandate to transform the higher education institution away from its "unintellectual, non-academic, almost civil service-like" roots often made headlines because of the racial tension this caused.

Pityana is the first to recognise that his appointment was something of a surprise. He did not have much of an academic footprint at the time and never was a career academic. His inaugural address set the tone for his life at Unisa:

"After a life of rather detached association with the academe, I find myself at Unisa to have my prejudices challenged or confirmed. I came as an activist and an organic intellectual whose theatre of engagement and laboratory was the world out there. I came also to challenge by my presence here some of the stuffy arrogance that, rightly or wrongly, I have come to associate with academics."

Pityana, who completed an LLM in Labour Law while serving the institution, used his own growing publication record to show his academic staff that it was possible to fit academic writing into the day-to-day challenges of academia. These days he is widely published on issues such as human rights law and theology.

In 2007, he was among the unsuccessful candidates for election as the Anglican Archbishop of Cape Town. He regularly spoke on the world stage, and was invited as a keynote speaker at the UNESCO World Conference on Higher Education in 2009. He became an exponent of Open and Distance Learning in Africa, served two terms as founding Chairman of the African Council of Open and Distance Education (ACDE), and on the ex-

ecutive of both the ACDE and the International Council for Open and Distance Education (ICDE).

Looking back at his life's work, Pityana realises he was often called on to "rescue situations and places". After he had retired from Unisa in December 2010, the Anglican Church asked him to regenerate the College of the Transfiguration in Grahamstown where its clergy are trained.

SECOND RETIREMENT

Upon his second retirement in 2015, he set his sights on writing, spending more time with his three grandchildren and enjoying his farm in Addo. His current academic ties include being an Honorary Visiting Professor of Rhodes University's Allan Gray Centre for Leadership Ethics, being an emeritus Professor in Unisa's School of Law, and serving on the Council of Wits University.

He led UCT's Convocation as President for one term from 2015, and in the same year was elected as Fellow of the Stellenbosch University Institute for Advanced Studies (STIAS), and worked on The Effects of Race research project with Profs Nina Jablonsky and Gerhard Mare. In 2016, he was a guest researcher at the Nordic Africa Institute of the University of Uppsala in Sweden.

This founding Member of the ASSAf serves as one of its Vice-Presidents and represents the Academy in the Network of African Academies of Science, of which he was elected Secretary-General in 2015.

The human rights activist in him is also not yet retired. Pityana, who is programme advisor to the Thabo Mbeki Foundation, frequently writes in the media or lectures about ethics and public morality.

"I believe that the best possible kind of activism for our country is one that seeks to help us to re-imagine a better future that combines both our social and intellectual activism for our world. Autocrats, even today, will that we may never will for the different or transcendent, or desire better than what is dished out to us. Even today, we are told that it is good for us to remain as we are. I beg to differ. My imagination and idealism tell me so."

| DAYA REDDY |

TOP THREE AWARDS

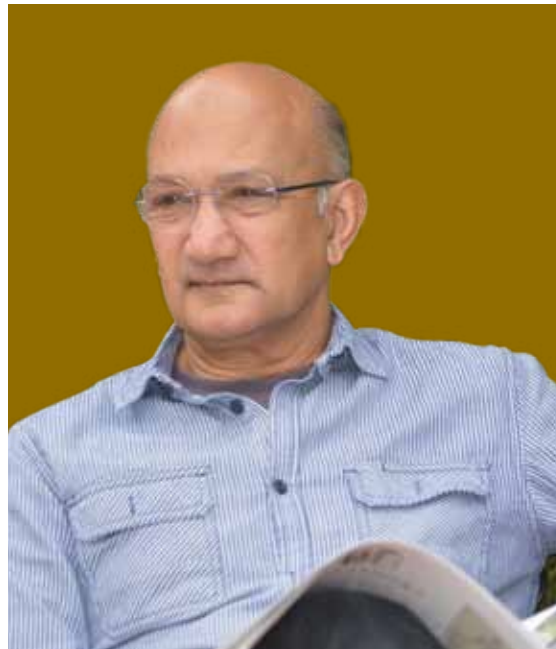
- Georg Forster Research Award from the Alexander von Humboldt Foundation, Germany, 2012
- Fellowship of the International Association for Computational Mechanics, 2008
- National Order of Mapungubwe (Bronze), 2004

DEFINING MOMENT

Being chosen as the next President of the International Council for Science (ICSU) at its general assembly in New Zealand in September 2014. It was “humbling and a great honour” to be only the second African elected for the post since ICSU was founded in 1931.

WHAT PEOPLE DO NOT KNOW

I started learning to play the piano when I was around 40 years old, at the same time as my son started to learn. He’s much better at it than I am.



A CHAMPION FOR SCIENCE

Professor Batmanathan Dayanand (Daya) Reddy isn't one to buckle under pressure, but his knowledge of things that do buckle under pressure is second to none. Finding out why and how things deform under strain has been a focus of his career in engineering and applied mathematics. A talented inter-disciplinary scientist, he has also worked with clinical scientists to develop models aimed at devising new therapies for heart disease, among other things.

A passionate science advocate, Reddy is one of South Africa's chief exports to the world of international science advice. Having served on several committees drafting evidence-based science advice on issues like climate and health, he is set to become President of the global International Council for Science (ICSU) in 2017, the second ever African to do so since the council was founded in 1931.

In addition to this, the University of Cape Town (UCT) Professor has also helped set up the Cape Town-based African Institute for Mathematical Sciences (AIMS) that trains graduates from all over Africa, and has given a fresh lease of life to UCT's Centre for Research in Computational and Applied Mechanics, Cerecam.

How on earth does he do it all? "I have great support," he says. His scientific colleagues and the excellent administrative staff and secretariats in the various organisations he works with have helped him to stay on top of his duties. He is also diligent and highly motivated – a prerequisite for someone who had to overcome racist policies under apartheid to get to where he is today.

EARLY LIFE AND EDUCATION

The son of a general store owner, Daya Reddy was born in 1953 in South End, near the Port Elizabeth waterfront. He had a happy childhood, but in his early teens his family had to move when South End was declared 'white' under the Group Areas Act. Not wanting to move to the area designated for Indians in PE, the family decided to emigrate to England. But the move didn't work out, and four months later they were back.

While their parents decided where to settle, Reddy and his younger brother lived with family members in the Johannesburg suburb of Vrededorp (which later was to suffer the same fate as South End). There, Reddy attended Lenasia Indian High School. He was a good student at high school, and especially talented at mathematics. It was his mathematics teacher, unqualified but gifted and dedicated, who suggested Reddy go on to study engineering at university. "I had never met an engineer. But the opportunity to use mathematics in my daily working life attracted me," Reddy recalls.

After finishing his matric, Reddy moved to Cape Town where his family had ended up settling. However, continuing with his education in Cape Town was tricky for Reddy. According to apartheid laws he was to study at the University of Durban-Westville on the other side of the country. But the Reddys could not afford to support him away from home.

Reddy had to apply for a special dispensation, or permit, to study at UCT. Permission was granted by the Department of Indian Affairs (as the relevant government office was called at the time), and he was able to enrol for a civil engineering degree at UCT. The university, he recalls, was "a different place" back then. He and the other black students, who were in a small minority, kept to themselves. "We had no social life whatsoever to speak of within the university," he says.

To start with his post-degree plans were straightforward. The bursary he had obtained from a construction company for his engineering studies came with a work obligation, and he intended to join the company upon graduation. But the head of civil engineering at UCT, Professor John Martin, had another idea. Martin, a South African, had returned after a PhD at the University of Cambridge in the UK and ten successful years at Brown University, an Ivy League institution in the USA. If Reddy was interested in postgraduate studies, why didn't he look into going overseas?

Reddy did. He applied to a few universities in America as well as to Cambridge, and was awarded the Smuts Trust Bursary for graduate research at the latter.

Reddy arrived at Cambridge in mid-1974. It took him a while to settle in. Initially he missed home. But in due course his social life picked up. He played cricket at college level, and toyed with the idea of rowing but was put off by the early mornings. He also enjoyed attending the debates at the Cambridge Union.

He found being a postgraduate student much more enjoyable than his undergraduate degree. Cambridge encouraged independence in research, and this suited him. "The freedom of not having all those courses and projects was such a relief," he says.

ACADEMIC LIFE AND RETURN TO SA

Reddy was awarded his PhD degree from Cambridge in 1977. He was only 24 years old. At the time, he thought he might return to South Africa. He had kept in touch with John Martin at UCT, and wrote to him about opportunities. Martin encouraged him to apply for a position that was advertised in his department. Reddy did so and was offered the position, but then declined it. "It wasn't about not wanting to come back to apartheid South Africa. I just felt like staying on," he says.

Instead, he spent a year at University College London as a postdoctoral researcher, investigating the circumstances under which thin bodies buckle. The work, which was closely related to his PhD research, addressed a problem in the North Sea oil industry. The oil was transported to land using pipelines on the seabed. The pipelines were fed off a boat, but if they curved too severely they would kink and buckle. Obviously, that was something that the oil companies wanted to avoid.

But the postdoc didn't work out too well for Reddy. His vision was at odds with that of his supervisor, who found Reddy's approach to be too theoretically oriented. After about a year, Reddy once more contacted John Martin at UCT. He was told that the position he had been offered had not yet been filled, and that if Reddy was still interested, it was his.

Reddy moved back to Cape Town in 1979 to a position straddling the departments of applied mathematics and civil engineering at UCT. The joint

appointment was the brainchild of Martin and George Ellis, at the time head of applied mathematics; the two had for some time been keen on building interdisciplinary bridges between engineering and applied mathematics. Reddy took up the joint appointment, and by 1987 was an Associate Professor. In 1988, however, he felt the time had come for him "to choose one home". He opted for applied mathematics, where he has been a full Professor since 1989.

Throughout the 1980s, Reddy toyed with the idea of going abroad again. But he enjoyed being close to his family, and shortly after returning from the UK had met his wife-to-be, Shaada, a librarian at UCT. They married and have a son, Jordi.

What is more, work kept him busy. He relished using mathematics to solve problems that cropped up in engineering. He would as readily participate in conferences organised by mathematicians as those run by the engineering community. His engineering background meant he could 'speak engineer', while also having the mathematical background to bring to bear in the study of problems arising in engineering applications.

Such an approach was closely linked to the domain of computational sciences, an area that has grown rapidly with the advent of more powerful computers. This peer methodology, existing alongside theory and experiment, allows automobile or aircraft manufacturers, for example, to simulate complex situations in design processes, thereby reducing the need for expensive experimentation.

However, Reddy's work soon went far beyond the inanimate. Together with colleagues in cardiovascular surgery and in industry he developed a research programme aimed at simulating the behaviour of artificial heart valves and other implants. This work has translated to real medical benefits, by informing the design of stents and valve implants.

Reddy has also used his applied mathematics wizardry to help palaeontologists understand aspects of the behaviour of extinct mammal-like reptiles. The collaboration came about as a result of a chance conversation with a UCT palaeontologist, he says, and has resulted in some well-cited work.

They shared a postdoctoral researcher. "She was working on mammal-like reptiles, and ended up spending three years here at Cerecam. That was real multi-disciplinary work, bringing together anatomical expertise, imaging based on CT scans of fossils, and computational simulation of mechanical behaviour."

DEMOCRACY, DEANSHIP AND DEVELOPMENT

Reddy's life as an academic and as a South African changed as the country went through its political upheavals. During the late 80s and early 90s, even as a staff member at UCT, he considered himself somewhat of an outsider in the white-dominated faculty. That began to change in the early 90s as South Africa's apartheid regime was dismantled. Nevertheless, the changes weren't always as rapid as he would have hoped. The Reddys enrolled their son at the South African College School (SACS) in Newlands, one of the province's best, but with an overwhelmingly white student body. This was in 1992, not long after formerly white schools became open. Although their son thrived, Reddy himself often despaired at the unwillingness of the leadership and many of the parents to embrace change.

Between 1999 and 2005 Reddy was Dean of UCT's Faculty of Science. He then decided to focus once more on teaching and research, rather than continue in the world of university leadership and management. He was awarded a research chair in 2007 in computational mechanics. He was part of the group responsible for establishing the Centre for High Performance Computing, a national facility. He threw his energies into resuscitating UCT's Centre for Research in Computational and Applied Mathematics. Under his leadership, Cerecam has blossomed, with students and staff hailing from a dozen African countries.

Mindful of the challenges facing bright students in the rest of the continent, he also worked with others to help establish the African Institute for

Mathematical Sciences, or AIMS, in Muizenberg. Students from more than 20 African countries have enrolled at AIMS for a postgraduate qualification, and many have gone on to study further at universities around the world. He is passionate about teaching and supervision, and loves seeing his students succeed. He has also spent stints abroad as a visiting professor in the USA and Germany, where in addition to collaborative research he has been closely involved in the work of his colleagues' students, some of whom have spent time with him at Cerecam.

In recent years, Reddy has become a champion of science and technology in wider society. In 2012, he became President of the Academy of Science of South Africa. The year after, he was elected Co-Chair of the InterAcademy Council, and also represents South Africa on the executive of the IAP, formerly the InterAcademy Panel and now the InterAcademy Partnership.

As he sees it, the task of these organisations is to strengthen the scientific enterprise generally, to promote science in broader society, and to provide evidence-based science advice to policymakers. He wants to increase ICSU's African membership and ensure greater involvement of its existing African members, believing that it's time that the continent starts to feature more prominently in the international science community.

There isn't much time left in Reddy's day once all his work duties are done. In spare moments he likes to read. Not about science, but good literature, both fiction and non-fiction. He enjoys the challenge of learning a new language. And he likes to listen to music, classical and also 70s Rock. But even while reading, enjoying his music or out walking, he rarely stops thinking about his work. It's just the way he is, he admits. "This dog has got to have a bone to chew all the time".

| HELEN REES |



TOP THREE AWARDS

- Order of the Baobab for contribution to medicine and medical research, 2016
- Oppenheimer Fellowship, 2015
- ASSAf's Science-for-Society Gold Medal, 2011

DEFINING MOMENT

Meeting my husband (I remember the moment) who in so many extraordinary ways changed the trajectory of my life.

WHAT PEOPLE DO NOT KNOW

A little known fact about Prof Helen Rees is that the first grant she raised was from the German government to provide first-aid training and services for township communities during the apartheid years.

ACTIVIST DOCTOR TURNED HEALTH POLICYMAKER

The offices of the University of the Witwatersrand's (Wits) biggest entity, the Reproductive Health and HIV Institute (Wits RHI), sit on a noisy corner of Hillbrow in Johannesburg. Unbeknown to themselves, many of the passengers passing by in hooting taxis have benefited from the insights of the Institute's more than 600 staff members: be it through the research done on HIV and sex workers, or through how findings about abortions, contraception or immunisation have informed government policy and guidelines.

Wits RHI's forerunner, the Reproductive Health Research Unit (RHRU) was set up in 1994. In 2010 it merged with another Wits entity, Enhancing Children's HIV Outcomes (ECHO), which specialised in the study of HIV among children.

Since its inception, the institute has been led in an exemplary way by its Executive Director, Prof Helen Rees. She has a self-proclaimed interest in matters relating to public health and prevention, be it through vaccines or contraceptives, or through helping to write guidelines and policy to prevent HIV infections the untimely deaths of young women and men.

"Vaccines and immunisation, along with contraceptives, are among the most powerful public health tools we have," elaborates this Professor in the Wits Department of Obstetrics and Gynaecology and the Co-Director of a newly established Wits Flagship programme in Vaccinology. "Both technologies have a massive impact on the well-being of populations."

HYBRID LEADER

So too has Rees, who describes herself as "a hybrid between a researcher and a public health policymaker."

This former activist doctor has evolved into a superb public health strategist with incredible reach. She is widely recognised for her contribution to researching HIV prevention, reproductive health, contraception and vac-

cines, and her particular ability to translate research into policy and practice.

Admired for her thoroughness and calm demeanour, Rees has chaired many national endeavours focusing on among others AIDS, TB and sexually transmitted infections. She is the current Chair of the South African Medicines Control Council.

Her expert opinion has been called on by many global institutions, including the World Health Organisation (WHO), UNAIDS and the US National Institutes of Health. Most notably, Rees chaired the WHO's overarching expert committee on immunisation (SAGE) and now leads the WHO's African regional expert committee on immunisation.

Rees is currently rapporteur for a WHO committee evaluating the global response to Ebola under the International Health Regulations and is serving on a WHO Emergency Committee responding to the Yellow Fever outbreak in southern Africa.

EARLY YEARS

A deep-set desire to address society's wrongs lies at the heart of these endeavours.

From a Welsh background, Rees was brought up in Hertfordshire, England, and was head girl of her school where she also excelled academically. In 1969, during one of her last years' of school, she was for instance a representative to the International Youth Science Fortnight held in London.

Her mother was a Welsh methodist and her father a Welsh socialist and both influenced her greatly. She obtained both a medical degree and a Masters in social and political sciences from Cambridge University. Free time as a student was often spent on human rights activities, ranging from running a Medicine in Society group in Cambridge to protesting against the 1970s Springbok rugby tour and in the 1980s, the installation of cruise missiles in the UK.

While still in England she made a South African contact – her would-be husband and fellow physician, Dr Fazel Randera, who was studying in London. The couple first worked together at Harare Central Hospital after Zimbabwe became independent. In 1984, they returned together to South Africa. As a mixed-race couple they faced harassment under apartheid legislation such as the Immorality Act and the Group Areas Act.

The couple joined the National Medical and Dental Association (NAMDA) that supported the liberation struggle in the health sector, and provided medical care to victims of political violence. Rees cared for many political detainees who had been victims of torture, and jointly authored a report to Amnesty International on the human rights abuses that occurred.

“The first grant I raised was from the German government for first-aid training and services for townships communities that at that time were under siege,” she remembers.

Rees spent most of her time at the Alexandra Health Centre, a clinic and teaching facility of the Wits Faculty of Health Sciences. It provided much-needed health services to about 500 000 township residents. She also coordinated the rural block training for Wits community medicine.

At the time, motherhood, the political struggle, township warfare and working as the Head of Paediatrics in Alex Clinic took centre stage. She had her second and third child during this period.

“As a collective of progressive doctors, the focus of our work in Alex was about righting injustices and providing services to a community with enormous health needs,” she provides context.

A serious measles outbreak in Alexandra triggered her very first scientific paper in 1988. “We had recurrent measles outbreaks, which in these communities equated to high mortality,” she sets the scene. “I wanted to understand why these babies were not being immunised.”

“Prior to that I had frankly not given research much thought as a career possibility,” she admits.

NEW DIRECTION

With the political changes of the early 1990s came the opportunity for Rees and many fellow health activists to move from the fringes of the health sector into more pronounced roles.

Rees has had a longstanding interest in reproductive health. In the early 1990s, she was part of a team of female researchers whose stark data showed how unsafe abortions were annually a matter of life and death for thousands of mostly black women. Their persuasive evidence helped Parliament frame the 1994 Choice of Termination of Pregnancy (ToP) legislation as one of the first major changes of the new democratic health system.

The RHRU was born out of a meeting with the then newly appointed Minister of Health, Dr Nkosazana Dlamini-Zuma. At the time, Rees was coordinating and writing the African National Congress’ (ANC) new policy on women’s health.

The idea of a unit focusing on issues of women’s health and reproductive issues had global traction, as 1994 was the year of the United Nations International Conference on Population and Development. The event, which is only held once per decade, recognised that reproductive health and rights, as well as women’s empowerment and gender equality, are cornerstones of population and development programmes.

“It was clear that there was going to be a need to support government to develop and implement new policies, and to undertake research while also supporting training, implementation and evaluation,” she summarises the thinking behind the endeavour.

A core group of five people started up the RHRU at Wits. Rees and Dr James McIntyre were the ‘ideas people’ whose vision was shared by people like Dr Mags Beksinska who could make it work on a practical level.

Rees acknowledges how she has always had the good fortune of working with motivated people whose skills and personality complement her own.

"Working with extraordinary people who are totally committed is what has made Wits RHI grow," she notes. "The leadership that RHI now has is outstanding and has expanded our work into new priority areas".

In a 2011 profile interview in *The Lancet*, she describes working at Wits RHI as such: "It is an extraordinary place with exceptional young African and global talents who are now holding their own in the health arena nationally and are a source of great pride for me. The country's history of activism has bred a generation of clinicians and researchers who have confronted all the new health challenges with fire in their bellies."

This hard worker really dislikes taking things on if she "cannot do it properly". "If I go onto a committee I don't want to do a half job; I really do get very frustrated if that's the case," says Rees.

Admittedly, her arm is sometimes twisted to take on tasks that she perhaps should not, but never something she doesn't believe in. "No, no, I certainly will not do it, it comes emphatically."

RESPONSIBILITIES AS CHAIR

Rees recognises that her appointment in 1998 as Chair of the Medicines Control Council changed the trajectory of her life. It catapulted her onto the world health stage, not only because of her regulatory oversight, but because it opened new doors. She was asked to chair global WHO meetings and to join organisations, such as the International AIDS Vaccine Initiative.

One such responsibility led to another. She has since developed into something of an expert chair – and a professional traveller too whose commitments take her around the globe.

In 2015, Rees was again asked to lead the Medicine Control Council. It's an opportunity she relishes, as the second time round she feels she has much more experience in drug regulation and in the health sector to fall back on.

Rees believes that self-doubt often hinders women's success in science and in leadership positions. "Many women, myself included, often quietly think it is a mistake when others ask them to take on a task," explains Rees. "Our first inclination is to say 'Really, me?'"

She shares two lessons she has learnt over the years. "If someone asks you to do something, they obviously believe you can do it. While you might be stretching yourself you should also believe that you are worthy of that request."

Rees also believes that women can work and successfully bring up children." Fazel and I both worked hard, but we made sure that we always had quality time with our children as they grew up. Our greatest pride now is the three fantastic young people that they have become."

Her successes in academia are not bad for a researcher who does not hold a PhD.

She reflects upon it as something that is not terribly amiss, but rather as the result of a different career focus during the struggle years. Had she pursued an academic path from the outset "then I would have had a totally different life. I would not have changed what I did even if it meant I would have had a PhD".

Notwithstanding, this lifelong scholar believes in actively developing her skills when and where necessary. In 2002, she completed the Harvard Business School Senior Executive Programme for Southern Africa.

"You need to keep learning; it's absolutely critical," is her advice to others working in academia, health, medicine or science. "Keep on wanting to push the boundaries of your knowledge, wanting to talk to your colleagues, wanting to have new ideas."

| MICHAEL SAMWAYS |

TOP THREE AWARDS

- IUCN Chair's Citation of Excellence, 2014
- ASSAf's Science-for-Society Gold Medal, 2008
- Gold Medal of the *Suid-Afrikaanse Akademie vir Wetenskap en Kuns*, 2016

DEFINING MOMENT

My first memory is of watching grasshoppers in long grass. I must have been three or four years old. I was fascinated by them, how they lived, what they thought, how they went about life. From that moment, I never wanted to do anything other than work on insects.

WHAT PEOPLE DO NOT KNOW

I once had a face-off with a green mamba at the top of a citrus tree in Mpumalanga. I was collecting samples when I spotted the deadly snake only 50 cm away. I calmly told it: "You aren't going to bite me, are you, and I shall not bite you." The snake must have understood, because we both slowly backed out of there, each unharmed.



FOR THE LOVE OF INSECTS

Whether traipsing around a Stellenbosch vineyard or scuba diving in the Seychelles, Professor Michael Samways' quest is always the same: To discover ways to safeguard local animal and plant life while at the same time allowing for reasonable exploitation of the local resources.

For a conservationist, he is refreshingly pragmatic. "It's all very well sitting in ivory towers saying we all have to love nature. But to actually do something about it, you have to engage with the people who use the land, or who live on it," he says.

For the interview, we sit in his Cape Winelands kitchen, which offers breathtaking views of the Hottentot Hollands mountain range. The mountains are old, he explains, much older than the Alps. For millions of years they have been a natural refuge that has led to the Cape evolving its unique biodiversity, he says.

Today, of course, many of the region's endemic species are threatened by invasive plant species. Part of his work at Stellenbosch University (SU) in the Department of Conservation Ecology and Entomology, has been to devise ways to reinstate and strengthen the original ecosystems so they can cope with new threats.

Samways' research has ranged from pest control in citrus farming to landscape ecology and environmental ethics. But he has always been most fascinated by insects, and much of his work has converged on illustrating just how important the services are that creepy crawlies render in nature, such as regenerating soil and pollinating crops.

EARLY LIFE AND EDUCATION

Samways himself is an alien of sorts in these parts. Although resident in South Africa since the mid-1970s, he grew up in rural England in the 1950s and 60s. As a child he wandered through the woods and fields of the Chilterns, marvelling at the natural world around him.

At school, he won prizes for biology, and in the sixth form (British matric) he won the prize for zoology. He enrolled at the University of Nottingham to study zoology, and although by his own admission he didn't take his formal undergraduate courses that seriously as he liked to read around much more widely. He graduated with honours in 1971.

If university wasn't serious business to Samways, nature, by contrast, was. During his student days, there were signs all around him that the natural world was struggling with unprecedented pressures brought on by human activity.

In 1969, the British conservationist, Peter Scott, published a book on endangered animals. Scott's *The Red Book – Wildlife in Danger* was a forerunner of the Red List maintained by the International Union for the Conservation of Nature, for which Samways would work later in life.

However, even in the late 60s, Samways was concerned by the lack of insects in the *Red Book*. The book focused on vertebrate animals. But from his own readings and experience, Samways knew that insect numbers were also dwindling, with some species from the old British records having disappeared entirely; "The world was getting poorer," he recalls.

Samways spent part of his PhD in southern France, tracking down and studying two species of bush crickets that his supervisor had heard about when he visited the area in the 1960s. The strange thing about the crickets was that their mating calls would interfere with each other, corrupting the message and making it harder for either species to find a mate. So why would they live in the same area?

Through his research, Samways found that the two species had indeed not evolved together. Instead, they had been pushed into artificial contact by changed land use in the region, caused by growth in the local city of Montpellier. This interaction between human development and the natural environment intrigued Samways and he wanted to study it more.

After receiving his PhD in entomology from the University of London in 1975 he took a correspondence course in tropical agriculture. Following that, in

the late 1970s, he went to Brazil as a visiting entomology Professor at the *Escola Superior de Agricultura de Lavras*, where he worked on producing fuel alcohol from cassava.

"I was going to save the world," he says. But what he saw in Brazil changed his mind about many things. Rather than a green alternative for generating power, the biofuel plantations he saw in Brazil were destructive monocultures. "We were making fuel out of this thin green veneer of life on the planet, and it was clearly devastating for biodiversity," he says.

Before Brazil, Samways studied the use of biological pest control in agriculture -- using natural enemies such as parasites or predators to keep crop pests in check instead of dousing fields in insecticide.

However, in Brazil he found that the enormity of the cassava fields meant that biological control agents could not penetrate into them, since they need a more varied ecology to thrive. "That's when I realised that extensive monocultures were not a good idea."

MOVE TO SOUTH AFRICA

In 1979, Samways was invited to Nelspruit in north-east South Africa to work at the Outspan Citrus Centre as a senior entomologist. It was an interesting part of the world, Samways reasoned, and he was keen to work on real-world problems. At the time, citrus trees in the region were badly hit by red scale, an insect pest that had become resistant to insecticides. To make things worse, widespread pesticide use had killed off the bug's natural enemies, and the infestation was so severe that trees were dying.

Samways looked to biological control mechanisms to solve the problem. There was a ladybird, *Chilocorus nigritus*, which feeds on the red scale insect. By introducing these ladybirds on a massive scale into the orchards, Samways and his colleagues managed to bring the red scale infestation under control. They solved the problem using nature's own ingenuity.

After seven years in Nelspruit, Samways was invited to apply for a Chair in Entomology at the School of Botany and Zoology at the University of Natal

(today the University of KwaZulu-Natal) in Pietermaritzburg. He applied and was accepted, even though he was still only in his thirties.

For the first time in his life he was a full-time academic. Mindful of insects still not being prominent in global conservation efforts, he began working on developing insect conservation as its own field. He started an Invertebrate Research Conservation Centre at the university, and was eventually invited to join the International Union for Conservation of Nature's steering committee as a specialist on invertebrate conservation.

Slowly but surely, insect conservation was getting a bigger audience. In 1995, a book written by Samways titled *Insect Conservation Biology* was published by Chapman and Hall in London to great international acclaim. During the 17 years that Samways stayed in Pietermaritzburg he embarked on ambitious conservation projects focusing on sustainable land use. For example, he worked with major timber companies in the province to develop large-scale ecological networks, leaving remnants of natural land scattered throughout the plantations. This allowed the natural biodiversity to survive, preserving the insects and invertebrates that scientists now know are absolutely crucial. It was one of the first projects in Africa to receive a grant at the time from the World Wildlife Fund that didn't focus on large mammals or birds, but on the land itself.

Also during his time in KwaZulu-Natal, Samways began working on tropical island conservation. The project focused on an island in the Seychelles archipelago called Cousine. The island had been exploited as a coconut plantation before 1968, but later was privately purchased to save the endemic Seychelles plants and animals.

From its severely degraded state, Cousine has been restored to its near-pristine natural state. Today it is a sanctuary for many species of animals and trees, including the Hawksbill turtle. In the Seychelles, and also on the KwaZulu-Natal coast, Samways studied coral bleaching, and developed a method of using butterfly fish as an indicator species for the health of the reefs. This was summarised in the book for which he was lead author *Tropical Island Recovery* published by Wiley-Blackwell.

LIFE IN THE WINELANDS

In 2003, Samways moved again, this time to SU in the Cape Winelands. Here he merged two departments – conservation biology and entomology – into a strong research centre with fruitful links with society and industry. He was Chair of the department until 2014, when he stepped back from the post but remained a Professor (now Distinguished Professor) in the department. During this time, he also published the major book *Insect Diversity Conservation* (Cambridge University Press) and was lead author for another significant book *Insect Conservation: Approaches and Methods* (Oxford University Press). Over his life he has also developed some more esoteric interests. His house is filled with art and sculpture, and he has authored a self-help book about finding love, harmony and happiness titled *Alchemy of Love* (Ayni Books, 2014).

At Stellenbosch, Samways and his team have worked with local conservation initiatives to make sure their work translates into impact on the ground. In collaboration with Working for Water, a national initiative that fights invasive alien plants, they were able to demonstrate the impact alien species can have on ecosystems, especially on water availability, and the speed with which indigenous species can recover once alien species are removed.

Working with the Biodiversity in Wine Initiative, his department has also played a key role in what Samways calls 'future-proofing' the wineries of the Western Cape. This has been side-by-side with extensive research in KwaZulu-Natal with the large forestry company, Mondi, to develop new approaches optimising timber production, while maximising conservation of biodiversity and ecosystem processes. The project has a dual benefit by making wineries and afforested lands not only environmentally sound and attractive, but also financially sustainable, since a light environmental footprint is at a premium when selling to certain lucrative markets such as Europe.

He says that he, as an academic, as well as industry representatives and large-scale farmers can learn a lot from interacting with small-scale farmers in South Africa who have an intuitive way of working the land sustainably. For instance, in KwaZulu-Natal he came across small-scale sugar cane

farmers who were not using any insecticides, but who relied on natural control measures.

Rural communities are also essential for conserving threatened species, he adds. A community in northern KwaZulu-Natal was found to be the home of a dwindling population of a rare butterfly, the Karkloof Blue. Overgrazing and veld fires were destroying the butterflies' breeding cycle. But once the villagers were told about the butterfly and how rare it was, and once they knew how to protect it by reducing grazing in the nesting sites and by creating fire breaks, they adopted the butterfly as the village emblem. Ensuring that the butterfly thrived thus became a community priority.

Because of success stories like these Samways enjoys his work as much as he ever has, despite the often-depressing news coming out of global environmental monitoring programmes. Conservation is a big puzzle, he says, and you need everyone to be involved – from the scientists to the villagers across to industry – to solve it.

The biggest bottleneck is economic pressure. Farmers and other land-users need to make money. But with the extra value being put on eco-friendly produce these days, he believes there are ways around this. The challenge is to change peoples' minds before it's too late. "To do something about things, you have to market the subject so that people know they can benefit from it. That's the real-life situation," he says.

His department at Stellenbosch hosts open days and school visits to encourage children to become more aware of environmental issues. This is an activity close to Samways' own heart. Having grown up with nature right outside his door, he feels for children today who don't get to play in nature because their parents fear for their safety, or simply because their teachers often find it difficult to take them outside.

"You don't need to live on the edge of a nature reserve to interact with nature," he says. Any urban park, any town common, will have insects that will allow children to interact with nature, just as he did in the Chilterns as a child. "The variety of nature feeds our eyes and brains."

| BARRY SCHOUB |

TOP THREE AWARDS

- National Order of Mapungubwe (Silver), 2012
- Paul Harris Award from Rotary International
- First recipient of the Lifetime Achievement Award from African Society for Laboratory Medicine (ASLM), 2012

DEFINING MOMENT

“Three of the most significant challenges I have faced could be called the most defining moments of my career: In my youth, the challenge of creating a Department of Virology at Wits in 1978. Later, the challenge of creating the National Institute of Communicable Diseases in 2001 and now in my more senior years, the challenge of chairing the Board of the NHLS at a particularly difficult time in its history.

WHAT PEOPLE DO NOT KNOW

Schoub has a keen interest in natural history, religion and philosophy, and is a grandfather to seven grandchildren.



FOLLOWING IN THE FOOTSTEPS OF THE FAMILY

Barry Schoub knew he was going to be a doctor by the age of three. He hails from a family of doctors – his father, his brother and his half-sister were all doctors before him, and he says it made his decision very easy. “My dad told me when I was three years old, ‘You’re going to be a doctor’. My two sons are also doctors, so it runs in the family,” he says.

Now into his eighth decade on earth, Schoub started his academic career at the University of the Witwatersrand (Wits), graduating with his MBChB in 1967. He then moved to Stellenbosch University (SU), where he completed a specialisation in microbial pathology – “equal parts immunology, virology and bacteriology” – working at both Tygerberg and Groote Schuur Hospitals. Medical virology was in its infancy at the time, and Schoub says that he was attracted to the challenge and the newness of the field.

“It was well before the AIDS era, but also well before the haemorrhagic fevers, such as Ebola. The scientific challenges of dealing with viruses at that stage were quite significant. Techniques for detecting many important viruses hadn’t been perfected, and a lot of the biochemical and biophysical studies of viruses were still being developed.”

His MMed research during that time, which he completed in 1973, was aimed at finding new ways to detect antibodies against specific viruses. Schoub, who has more letters after his name than most (OMS, MBChB, MMed, MD, DSc, FRC Path, FCPATH, FRSSAf and MASSAf) describes his early work as “mundane”, but it set him on course for a successful career in virological research.

EARLY YEARS

Upon returning to Johannesburg in the 1970s, he joined the South African Institute for Medical Research (SAIMR) for around 18 months before being asked by Professor Wally Prozesky to join the University of Pretoria’s (UP) Department of Virology. Under Prozesky, then Head of Virology at UP, Schoub conducted research into infantile gastroenteritis in South African black populations to complete his Doctor of Medicine (MD) degree.

It was during this period that Schoub identified the first-ever case of rotavirus in an African population, which was published in the prominent medical journal *The Lancet* in 1975. Today, we know that rotavirus is the chief cause of severe diarrhoea in children, especially in developing countries. According to PATH (formerly the Programme for Appropriate Technology in Health), rotavirus still kills more than 200 000 children in Africa every year, despite the development of two effective rotavirus vaccines in 2006.

“We demonstrated that rotavirus was a cause of gastroenteritis in Africa, and that spurred the need for diagnostic techniques. It was important to demonstrate that a virus was the cause,” says Schoub when asked about the impact this work might have had. “I think the work showed the need to develop a vaccine, which we now have as part of the routine immunisation of children.”

Part of that research, which relied on data from clinical samples from Baragwanath Hospital and on studies in mice, also demonstrated the value of breastfeeding to prevent gastroenteritis and diarrhoea in infants. Schoub’s findings showed that mothers could transmit rotavirus antibodies in breast milk, a scientific result ahead of its time.

As a demonstration of just how contagious rotavirus can be (even in mice), Schoub had to isolate himself and his work. “I had to be kept well away from the mouse colony at UP – I was given a little dungeon to work in,” he says with a laugh.

After completing his MD, Schoub spent another year studying rotavirus in the laboratory of Dr Albert Kapikian, a prominent virologist at the National Institute of Health in the United States (US).

Schoub then returned home from the US and took up the post of Deputy Director at the newly-established National Institute of Virology (NIV), again under Wally Prozesky, at the age of 33. He was also appointed as the first Chair of Virology at Wits, which, he recalls, was quite a challenge to set up. He was responsible for managing and directing a small research team, which meant he spent less time on research and more on management



and administration. When Prozesky left the NIV in 1982 to become Deputy Vice-Chancellor at UP, Schoub replaced him as Director.

Not content with three degrees, two concurrent high-level research management jobs, and supervising student researchers, he went on to complete a Doctor of Science (DSc) thesis entitled *An Analysis of Viral Infections in Developing and Developed Communities in SA* in 1992. This thesis, which collated two decades of virological and epidemiological research into a single narrative, compared developed and developing communities to look for differences in the frequency and distribution of viral infections.

Schoub says this kind of epidemiological work has value when planning disease interventions: "If we understand the prevalence, how a disease is spreading – where, how, what demographic groups are affected, what ecological factors are affecting it – that can tailor-make your intervention." He found that infantile gastroenteritis and viral pneumonia were most prevalent in developing communities, while in developed communities, diseases like hepatitis A and glandular fever were more common. This clearly demonstrated that early exposure helped protect people against viral infections – privileged children were protected from many pathogens at a young age, so when they were exposed as adolescents or young adults, they remained susceptible and experienced the illness.

The study also showed the devastating effect of measles in South African black populations, and revealed early evidence of the HIV epidemic spreading into the general population. "I think my work has made a contribution to policy level interventions in SA – a small contribution," says Schoub, in his characteristically humble fashion.

With experience in epidemiology, virology and research management, it was a natural step for Schoub to be included in the World Health Organisation's (WHO) Advisory Committee for Polio Eradication (ACPE). During the 2000s, the ACPE oversaw the international effort to eradicate polio by providing policy recommendations to national health departments all over the world.

"When the eradication programme started in 1988, it seemed very simple, because we took lessons from the smallpox eradication campaign," ex-

plains Schoub. But it quickly became obvious that eradicating polio would be far more complex a task. For a start, most people infected with polio only carry the virus rather than showing symptoms. On top of that, there are complexities associated with the oral polio vaccine because it uses a live version of the virus.

"The oral polio vaccine is a live virus that multiplies and accumulates mutations, and can actually back-mutate to cause paralysis. "This necessitated some changes in immunisation strategies," says Schoub. However, he adds, the rate of paralysis is only one in every two million or so doses. The injectable, killed vaccine does not cause paralysis.

Other challenges the committee faced "were not virological but political" – it was a challenge to get buy-in from all health departments worldwide. Schoub also consulted on measles, influenza and respiratory syncytial virus for the WHO. For his work on polio, Schoub received the Paul Harris Award from Rotary International. While he is no longer part of the ACPE, he says that the WHO still calls on him from time to time for expert advice.

Meanwhile, back in South Africa, changes were afoot at the National Institute for Virology. Schoub explains: "I was involved in the transformation of the SAIMR to become the National Health Laboratory Service (NHLS), and the NIV to become the National Institute for Communicable Diseases (NICD)." Bacteriology, parasitology and microbiology research was added to human virology to form the NICD in 2002.

Schoub was the first Director of the NICD, and he speaks highly of the scientists and administrators who worked with him, attributing some of his research achievements to their hard work. "They say scientists are an irascible group, but I must be honest and say the ones I worked with, I really enjoyed their company – we were friends as well as colleagues."

One cannot mention epidemiology in South Africa without touching on the subject of HIV/AIDS; Schoub, of course, played a significant role in HIV/AIDS research. His DSc revealed early evidence that HIV was spreading in this country, and as Director of the NICD he oversaw critical work by pio-

neering HIV/AIDS researchers such as Lynn Morris and Caroline Tiemessen. He was also involved in setting up the first HIV research unit under the Medical Research Council of South Africa (MRC).

"We started to detect HIV in the white gay male population in the mid-80s, and then in the African population only in the mid-90s. We charted the expansion but also demonstrated the different subtypes." South Africa mostly has subtype C, while in the developed world it is mostly subtype B.

AIDS DENIALISM

What followed in later years was the dark period of AIDS denialism in South Africa, during which Schoub sat on the Presidential Advisory Council for HIV/AIDS (PACHA). While thousands died without access to antiretroviral drugs, the AIDS dissidents held the country hostage by pushing an agenda rather than engaging in scientific discourse around very real issues. "They were very uncomfortable, unproductive, negative get-togethers. There was no scientific discourse; these cowboys were punting an agenda that there wasn't evidence for," Schoub says. "I don't have a very loud voice, and I was shouted down."

The PACHA meetings led to a massive research effort at the NICD to prove or disprove what Schoub calls "dissident assertions" about the cause of AIDS, research performed in parallel with the Centres for Disease Control (CDC) in Atlanta, US. He says this research had some value in that "it showed how reproducible the serological tests (tests based on blood and other bodily fluids) were. Our results and the CDC results were virtually 100% concordant, so that was one positive spin-off. Otherwise it was just a tremendous waste of scientific energy, let alone resources".

Schoub retired from his position as Director of the NICD in 2010, and had been working hard on his tennis topspin until May 2015, when he was asked to chair the board of the National Health Laboratory Service (NHLS).

Though he may not make the assertion himself, Schoub has undoubtedly made a tremendous and global contribution to public health.

| FRIEDEL SELLSCHOP |

TOP THREE AWARDS

- Max Planck Award, 1992
- Institute of Physics (Gold), 1990
- Order of the Baobab (Gold), awarded posthumously, 2002

WHAT PEOPLE DO NOT KNOW

Few people know that Sellschop loved classical music, and that he often sang arias from famous Italian operas.



STUDYING MESSENGERS FROM THE DEEP

In 1965, a Nobel Prize winner in the making, and a young Professor from the University of the Witwatersrand (Wits) set up research equipment three kilometres below the surface of the earth in a mine in Boksburg. Their aim was to find, in nature, evidence of minuscule particles called neutrinos. They had been theorised, and the Nobel Prize winner (to be) had found artificially-made neutrinos from a nuclear reactor, but none had been located “in nature”, although millions of them pass through every human body every day. Their research was successful – a naturally occurring neutrino was observed, the theory verified, and their importance as a critical part of our understanding of the kind of processes that go on in the sun, and as important building blocks for the blueprint of nature became invaluable. What is rarely acknowledged about this unusual research is that the researchers also identified, at the time, traces of the W Boson – although the W and Z bosons were formally discovered in 1983 by physicists at the Super Proton Synchrotron at CERN, (a global research centre where Sellschop was also involved). The Z Boson is a neutral elementary particle, a kind of ‘heavy light’. The W boson is an electrically charged cousin of the Z boson. The both carry the weak force – and they both have notable connections to neutrinos.

The young Wits Professor critical to this work was Jacques Pierre Friedel Sellschop, almost always known as “Friedel”, and who was, at the time, a Cambridge PhD graduate and the Professor of Nuclear Physics and the Director of the Nuclear Physics Research Unit. His Professorship was the first ever of its kind in South Africa.

EARLY YEARS

Sellschop was born in Lüderitz, Namibia – then an administered part of South Africa – and began his academic life as a school boy at the Christian Brothers College in Pretoria, leaving school with distinctions in mathematics and Latin. He enrolled as a student at the University of Pretoria where he completed a BSc degree *cum laude*, before going to Stellenbosch University to work towards an MSc degree, which was also awarded *cum laude*. Completing that research, Friedel left South Africa and embarked on his PhD research at Cambridge University. While at Cambridge, Sir Basil Schon-

land (a fellow South African) encouraged Sellschop to return to South Africa to seek out opportunities for research that were unique to South Africa. In this respect, Basil Schonland was probably one of the people who had the greatest impact on Sellschop's life.

He took Schonland's advice, returned to South Africa and, during that time, was appointed by Wits in 1956 and assumed his appointments as Professor of Nuclear Physics and the founding Director of the Nuclear Physics Research Unit in 1958 – both while he was still in his late 20s.

On subsequently taking up his positions, Sellschop set about turning the Department and the Centre into operational entities. The tasks he faced must have been daunting. Years later, an eminent physicist remarked, at a conference in Lüderitz, that a “true measure of Friedel's greatness was that he accomplished his ground-breaking research not in a super-duper laboratory with everything at his disposal. He accomplished what he did starting from scratch. Not only did he have to build the laboratory, but also a tradition of scientific research.” These observations are borne out in the reality of the time, as Sellschop was assigned the remnants of a disused mining and military hospital – and bare veld. In other words, he developed a world-class laboratory and research tradition by way of his own skills. It is appropriate that when the Centre was to be formally titled, it was aptly named after Basil Schonland who had encouraged Sellschop's return to South Africa and who had, previously, established the Bernard Price Institute, also at Wits.

It is important to bear in mind Sellschop's pioneering work since, during the challenges of developing the department and the unit, he continued and published his own research (including new work on the neutrino), laying the ground for a distinguished career in science.

While remarkably diverse, Sellschop's research focused on three major areas: neutrino research (particle physics), following on the 1965 discovery; diamond physics – across a wide spectrum of specific issues (and for which he was awarded the Max Planck Award); and geosciences, related to his diamond research, but studying diamonds as “messengers from the deep” containing elements of the earth's mantle, “well preserved in a chemical

and physical prison" the only way of gaining insights into the detailed nature of the mantle. These elements came from points 200 kilometres below the earth's surface, and were formed 2.5 billion years ago – where and when diamonds had their origins.

Sellschop's research in the area of diamonds brought him into contact with Dr Henry Dyer, then Managing Director of the De Beers Industrial Diamond Division. Their friendship and shared knowledge almost certainly made Dyer a second major influence in Sellschop's life and research.

His research in the field of diamond physics was broad and (by now) internationally well known and respected thus having him participating in the CERN NA43 and NA59 collaborative research. In this role, he worked on experiments that used the perfect and very rigid "diamond lattice" of diamonds to produce and to study the highest energy, near monochromatic (single frequency) photons – photons being the smallest possible packet of light at a given wavelength. Diamond is a sufficiently perfect gem of a target that coherent effects are maximised at the expense of the incoherent.

Sellschop also undertook research – in the field of material science studies – that contributed significantly to the use of diamonds as 21st century "high tech" materials – taking their value way beyond the hard tips of drills. In this regard, he also studied ion-implantation of diamonds and was a pioneer of diamonds as an ideal material for hosting electrical and optical applications.

Despite becoming the Dean of the Faculty of Science at Wits in 1979, and the Deputy Vice-Chancellor for Research in the university in 1984 (a post he held for 13 years) Sellschop's research continued so that, when he retired, he was immediately awarded the Schonland Honorary Professorial Research Fellowship, and in 1998 became a Professor Emeritus of the university.

TIRELESS WORKER

Sellschop was a tireless worker, no matter in which field, or on what task, he was working. He had two desks in his study at home – one for sitting

and the other for standing. When, in the early hours of the morning he felt himself falling asleep, he would move to his "standing desk" until, when even that failed, he would take a quick, cold swim, and return to work. In addition to being a tireless researcher, Sellschop was (unlike his Cambridge supervisor, whom he met twice) an assiduous supervisor, who met with his doctoral students at 09:00 each Saturday morning to review their progress and discuss their work.

In recognition of his exceptional contributions to a broad range of topics in physics, several fellowships were awarded to Sellschop. In 2000, in honour of his 70th birthday, the International Conference on Fundamental and Applied Aspects of Modern Physics was held in Lüderitz, Namibia – his home town. So widely international and respected was the conference that the entire town of Lüderitz participated in, and contributed to, the success of the conference.

In addition to being a special advisor to the Ministry of Arts, Culture, Science and Technology for five years, he was a member or fellow of 11 South African and four international professional bodies, and served as a committee or council member on all of them. These included, among others, the South African Institute of Physics; the Joint Council of Scientific Societies (of which he served as Vice-President, and twice as President); the Council for the Natural and Scientific Professions; and the Royal Society of South Africa (where he also served a term as President); and on the Commission on Nuclear Physics of the International Union of Pure and Applied Physics.

Wits donated the Schonland Research Institute for Nuclear Sciences to the National Research Foundation (NRF) in 2004, and it then became one of the two sites of the NRF's iThemba Laboratory for Accelerator-Based Sciences, or iThemba LABS. At that time, Simon Connell, one of Sellschop's doctoral students and now a professor of physics at the University of Johannesburg, and Friedel's widow, Sue, decided that Friedel's role in initiating the original centre, and in its growth and development over many years, should not be forgotten. To this end, they secured space in one of the Johannesburg buildings of iThemba LABS and succeeded in having it named the Sellschop Room. In the room, they assembled many of his books (not just on physics, but covering an entire range of his areas of in-

terest), work by his students, photographs, and memorabilia. The Sellschop Room is a tribute to a great researcher – and an invaluable resource for anyone wishing to know more about his work and life.

MODERN-DAY RENAISSANCE MAN

Few people know that Sellschop loved classical music, and that he often sang arias from famous Italian operas (mainly to himself) in the evenings – and that, as a young man, he played the bagpipes and never lost his love for bagpipe music. What is more, despite the substantial time he spent undertaking his research, and the considerable demands made on him by his professional work and public life, he was, at heart, a deeply committed family man – and one whose research work was sustained as much by his sense of enchantment as by the hard-science research and its outcomes. Against this remarkable background, it is not difficult to think of Sellschop as a modern-day Renaissance man: an internationally respected and highly honoured physicist, a geo-scientist, an avid reader of the classics (which

he frequently quoted) and of autobiographies; an engaged follower of palaeontology, a budding musician and lover of a wide range of musical traditions (especially opera, including Gilbert and Sullivan).

How better, though, to know this remarkable man, than through this simple message (type-written on an official university letterhead from his professorial office):

*Dear Barry
Please excuse for the delay in replying. I'm thinking.
Kind regards
Friedel*

The writer wishes to acknowledge the considerable help given, and information shared, by Professor Simon H Connell, who provided information about, and insights into, the life and work of Professor Friedel Sellschop.



| OLIVE SHISANA |

TOP THREE AWARDS

- Academy of Science of South Africa Science-for-Society Gold Medal, 2013
- One of the top 100 world-class South Africans, 2013
- Honorary Doctorate of Law from Monash University, Australia, 2003

DEFINING MOMENT

When Shisana was struggling to find her voice in the classroom, a friend of hers said, "You are going to have to raise your hand to get those marks or else you are going to fail". Still, Shisana was too afraid to raise her hand. One day in class, her friend took Shisana's hand and raised it for her – "She has something to say". Shisana made her first input in that class that day in 1977. "It was a breakthrough for me. I don't think I would have made it in the US if I did not have (now Dr) Sue Minsky by my side having confidence in me and telling me that I had something interesting to say. To succeed, we all need supportive people who believe in us."

WHAT PEOPLE DO NOT KNOW

"I have cows." You have cows? "Yes, nobody knows about them." Shisana has 14 Friesland and Jerseys at her farm in Polokwane.



FILLING A GAP ADMIRABLY

Dr Olive Shisana grew up in a period of South Africa's history when it was hard to realise one's dreams.

After she matriculated in 1970 from Lemana High School near Louis Trichardt, she wanted to go into clinical psychology. "However, this degree was reserved for whites, so I wasn't allowed to do it." Instead, she started with a degree in social work and psychology and completed her BA in social sciences in 1973 at the University of the North (now University of Limpopo). It was during this time that she became politically conscious. She was there when Abram Tiro was expelled for criticising the Bantu Education system, and she participated in major demonstrations about his expulsion and about education. Her continued participation in anti-apartheid activities led to her exile in 1975.

After spending a year in Mozambique and a few months in Tanzania, she moved to the United States with assistance from her family in the US and the African National Congress (ANC). This finally allowed her to pursue a Masters degree in clinical psychology at Loyola College in Maryland.

Studying in the US was very different from her studies in South Africa. "I grew up in a country where women were not supposed to be forthright. In the US, the only way I could pass my classes was to contribute to the discussion. The discussion counted, it had marks." She was nervous about making a mistake or not making sense. However, a friend encouraged her to speak up and so she became more assertive in the classroom. This allowed her to engage with and succeed in her studies. Throughout her studies, she maintained her role as a political activist, specifically in her leadership roles as the Chairperson of the African National Congress (ANC) in Washington, DC, the Chair of the women's section of the ANC in the US, and member of the South African Women's Day Committee, which organised anti-apartheid activities in Washington DC.

Later, when she started her doctorate at the University of South Florida in Tampa, Florida, she discovered that clinical psychology was not her calling.

"I couldn't focus on hospitalised individual psychiatric patients. I thought I'd never be able to make a difference like this." She left Tampa after one year and started a doctor of science degree at the Johns Hopkins School of Hygiene and Public Health. Her specialty was the social factors in health and illness (now termed social epidemiology).

The move from clinical psychology to public health gave her a new perspective on health. In clinical psychology, she had been restricted to providing care for one patient at a time. By switching to public health, she was able to protect the health of a community. This level of protection was more holistic and comprehensive. Public health encompassed not only the psychological aspects, but also the medical and social aspects. "I felt like this gave me a broader understanding of human beings and the system that cares for them."

After graduating with her doctorate from Johns Hopkins University in 1984, she took a job as a researcher and health statistician for the local government of Washington DC. It was here that she realised the tremendous impact HIV was going to have on the world. "I worked on vital registration (births and deaths) and often looked at death records." Within these records, she often came across unusual causes of death, such as Kaposi's sarcoma. While healthy individuals shouldn't have died from such diseases, individuals living with HIV are susceptible to opportunistic infection that can cause devastating illness. Shisana suspected that the underlying cause of death in some of these records was actually HIV and worried about the impact HIV would have in the future. "This can start small, but it is an infectious disease. And since it is an infectious disease that can be transmitted from one person to the other, we are likely to have a big problem if we don't nip it early."

CHOOSING PUBLIC HEALTH

When she returned to South Africa, she decided to continue in public health instead of going into politics. She helped the Western Cape establish the Western Cape School of Public Health (1991 – 1993) and acted as a Research Specialist for the South African Medical Research Council (1991

– 1994). She then reorganised and consolidated the National Health Department as a Special Advisor to the South African Ministry of Health (1994 – 1995) after which she served as Director-General for the South African Department of Health (1995 – 1998). She also served as Executive Director for Family and Community Health for the World Health Organisation (1998 – 2000). In these roles, she kick-started HIV/AIDS programmes with a goal of studying the epidemic and informing public policy.

This led her to pursue a job at the Human Sciences Research Council (HSRC). The HSRC is the largest research institute specialising in social sciences and humanities on the African continent. Its primary responsibilities are to create and monitor government policy, evaluate implementation of that policy, and effectively distribute research results to a broader public audience. The research conducted by the HSRC covers a range of fields of science and technology, democracy and governance, health and education. The commonality among these topics is their aim to improve and uplift the lives of the South African public. They stand by their claim; all HSRC publications are available to the public free of charge from their website.

Shisana joined the HSRC for a particular purpose. “It was not really because I was looking for a job, I was looking for a place to fill a gap.” Much of the HIV/AIDS research conducted in South Africa focused largely on the medical issues, but neglected the social determinants. “HIV involves behaviour, social structure, and economic issues.” The HSRC allowed her to open an office in Cape Town and supported her efforts to establish a national programme to study the social aspects of HIV/AIDS.

One of the first studies they conducted was a population-based survey on HIV/AIDS prevalence and behaviour. “It was at a time when President Thabo Mbeki and the administration denied that HIV causes AIDS and claimed that it wasn’t a problem for the country.” However, with the political background she gained in Washington DC, Shisana knew that through research and evidence, she would be able to inform policy.

The HSRC brought their proposal to former President Nelson Mandela and they were granted funding to document the extent of HIV. “The first policy

contribution that this study made was to convince the administration that HIV is real; that HIV affects black people; and that HIV can be addressed if there is commitment.” The South African National AIDS Council had just been established when Shisana was asked to become a member. “My membership meant that I had a platform to share scientific evidence with policymakers and non-governmental organisations to improve policy and programme development.” The HSRC report became the foundation for planning the South Africa National HIV/AIDS Strategic Plan. To a large extent, the plan was informed by the findings and recommendations from the population-based surveys, especially the Nelson Mandela/HSRC study on HIV and subsequent studies.

Shisana and her colleagues completed the fourth of a series of HIV prevalence and behaviour surveys, the first three being conducted in 2002, 2005, and 2009. These surveys have allowed the tracking of HIV incidence over time, as well as the provision of evidence for future prevention methods. Some of the main strengths of this survey include the large data set, the information specific to a demographic (region, race, gender), and the behavioural component, which investigates the relationship between sexual risk behaviours and HIV infection. “It has become a landmark study that people use to track the epidemic. It’s a barometer to measure the progress of this country in terms of how to deal with HIV.”

TAILORING THE MESSAGE

The report is an elegant document. It is a complete, extensive survey communicated in uncomplicated, direct language. Shisana explained how she had to re-learn how to communicate when she started spanning the gap between research and policy. “When you write for a publication, you are targeting people who will advance knowledge. When you interpret for the public, you must tailor your writing to everyone else’s level.” At first, she actually had to use a computer programme to assist with simplifying her language. Now, it comes more naturally. The 2014 report has clear language and well-presented data that make it informative and easy to read. This final report will be submitted to all key stakeholders after it is published. “Once the report is published then other people can interpret it,

but we want to give our interpretation first. Others are free to interpret it differently."

Although the main findings of the report state that HIV incidence has remained stable (though high) in the last decade, Shisana and her colleagues were surprised by the drop in knowledge levels and a stagnation of behavioural change from 2008 to 2012. "Suddenly, people didn't really have correct knowledge of how HIV is transmitted and how to protect themselves." The report showed a lower condom use rate and a higher incidence of multiple sexual partners. Shisana suspects the drop in knowledge is partly because of the success of HIV/AIDS treatment. "Up to 2008, people were taking HIV very seriously because they saw someone die from HIV. They knew people who were living with HIV. The ARVs make the risk less apparent. Also, those who were educated have aged out of a high-risk category, so they think HIV won't affect them."

Shisana worries that money devoted to HIV treatment will be diverted away from research. "The budget for HIV must first address people's immediate needs." This will mean increased spending on ARVs and care. While the price of drugs has gone down, the virus will become resistant to first-line antiretroviral drugs and a second line of drugs will need to be used. However, Shisana is still hopeful of the future of research. "My hope for research is in the researchers themselves – there are more and more excellent young researchers." Shisana herself has invested in these up-and-coming researchers and believes the HSRC will continue fostering this new generation of scientists.

Shisana has just completed her ten-year tenure as the first black female CEO of the HSRC. However, she does not claim to be retired. "A colleague of mine calls it preferment, not retirement. I am now at the stage where I prefer and choose what I want to do." What she has chosen to do is to set up an international company called Evidence-based Solutions. She and her daughter have teamed up and are establishing offices in Cape Town and Atlanta. Their goal is to start a research programme and also investigate the application of telemedicine and telehealth. Telemedicine allows patients without access to specialists to be seen electronically. "If you don't have all of the skills on site, you can electronically refer the patient to a remote site. That remote site may be a hospital with specialists, which examines records and images electronically, sometimes in real time." The goal of this service would be to provide services to patients in remote rural areas. "We feel passionate about using technology to make health care accessible to rural communities."

Shisana hopes that young researchers know that being a scientist is not easy. "You work too many hours on publications, and when you submit your articles, they may be rejected. Don't take it that you are not good enough. Take it as an opportunity to improve on your writing skills." Instead of throwing rejected papers away, she encourages young researchers to find the journal that is interested in the subject. "If you devote five years of your life to being a good researcher, you will be a good one."

| SIBUSISO SIBISI |

TOP THREE AWARDS

- United Nations Scholarship
- National Order of Mapungubwe (Silver), 2007
- Fulbright Fellowship (CalTech), 1988

DEFINING MOMENT

Being stimulated by parents and teachers in a “critical defining environment”.

WHAT PEOPLE DO NOT KNOW

Dr Sibusiso Sibisi, Chief Executive Officer (CEO) of the Council for Scientific and Industrial Research (CSIR), is a runner, swimmer, cyclist, and he rows. This fitness for purpose, ability to perform, and to keep running (or rowing) until his goal is reached, are key characteristics that apply to many other aspects of his life.



A FITNESS FOR PURPOSE

Born in Mariannhill, close to Durban in KwaZulu-Natal, Dr Sibusiso Sibisi attended St Francis College in Mariannhill where he completed his Matric, avoiding the worst of apartheid's system of Bantu Education, while not escaping apartheid's seriously negative effects on the rest of his young years. His interest in science was supported and stimulated by his parents (neither of whom was a natural scientist) who, as part of their support, bought him a weekly series of magazines titled *Understanding Science* which deepened his curiosity; and by his teachers, the nuns at St Francis, who were good educators and who also stimulated his existing interest in physics. Sibisi believes that time in his life, which included a strong sense of focus, was what he calls "a critical defining environment".

Sibisi left school at the end of 1973 and, at about that time his mother, who had studied abroad at the University of Cambridge, was offered an academic post in England. His family moved from Mariannhill to Birmingham where, with a United Nations Scholarship (which supported him through to the completion of his PhD) he attended the Matthew Boulton Technical College, studying for, and writing, his A-levels – and was admitted to Imperial College, London, as an undergraduate working towards a BSc in physics. His results were so outstanding that his next step was to enter the Department of Applied Mathematics and Theoretical Physics (DAMTP) at Cambridge, where he completed the Part III – a graduate level course that would lead into a Masters or doctors degree. Sibisi moved directly into the doctoral programme and completed his Cambridge PhD in physics in 1983 – at the age of 28.

In these years, his focus of interest was in the area of probability theory and analysis, which is used to help draw inferences from large data sets in a range of disciplines, including, for example the vast arrays of astronomical data that will stream earthwards from the Square Kilometre Array. He feels that a paper, which he and his supervisor co-authored on this topic, is probably the greatest single research contribution that he has made to scientific knowledge. In addition, he feels that his commitment to translating

research findings into commercial and social applications, his strong sense of the relationships between research and innovation, have become part of his contributions to the wider field of science.

By the time that he had completed his PhD, Sibisi had published articles in two internationally respected scientific journals (one of which was in *Nature*) – a clear indication that ensuring fitness for purpose, his ability to perform, and reaching his goal were characteristics well established in his approach to life.

On completing his PhD, Sibusiso returned to South Africa to take up a position as a lecturer in applied mathematics at the University of the Witwatersrand (Wits). Moving into applied mathematics was perhaps an indication that his thoughts were already turning towards the importance of linking the results of research to their applications in ways that would benefit society and the economy. A Fulbright Fellowship took him to the California Institute of Technology (Caltech) – a university that consistently ranks along with Cambridge in the top ten universities in the world.

Sibisi returned to Wits as a senior lecturer in 1989, again in applied mathematics, but before the end of the year, he had been appointed as Senior Research Associate back at the DAMTP at Cambridge. In 1992, he moved to the famous Cavendish Laboratory, also in the position of a Senior Research Associate. The "Cavendish" is noted for being founded on collaborative research and teaching, which help to expand its research into new areas in which physics can make substantive innovative contributions to scientific knowledge and practical applications.

After just one year at the Cavendish, Sibisi (at the age of 38) became an Executive Director of Maximum Entropy Data Consultants Ltd in Cambridge, a company devoted to delivering results in complex areas of research to companies in need of support in those areas. These included, for example, general image deconvolution synthetic aperture radar; mobile telephony location analysis; seismic imaging and mass-spray spectrometry. His transition into the world of research and its application to society at large in valuable ways, had been completed.

AWAY FROM ACADEMICS

By this time, of course, Nelson Mandela had been freed from prison; the Convention for a Democratic South Africa (CODESA) was well advanced in its work, and the country was just a year away from its very first democratic elections in 1994. With a new government firmly in place, under now President Nelson Mandela, Sibisi was drawn back to South Africa to head research and development at the Cape Town headquarters of the continent-wide Plessey – one of Africa's major providers of ICT infrastructure that offers support to a broad range of elements in this complex arena. After two years with Plessey, Sibisi moved briefly back into academia, this time in a senior management position as Deputy Vice-Chancellor for Research at the University of Cape Town, before being appointed in 2002, to his current position as CEO of the CSIR – a moment that has probably been the most defining in his life. A researcher with applied and managerial knowledge; a firm commitment to tying together the worlds of research application and development; and the perfect leader for the 'cross-over' world of the CSIR. What is more, he is a CEO with the critical and essential characteristics that have been a clear part of his life from his youth.

For the past 22 years, Sibisi's work has effectively been in management positions, yet his commitment to and engagement in research have continued. He co-founded iThemba Pharmaceuticals (Pty) Ltd in 2001, which is focused on helping new technology businesses with analyses and strategies. His versatility also saw him provide the vision and leadership of a team that conceptualised, planned and established the Meraka Institute (African Advanced Institute for Information and Communications Technology) in response to President Thabo Mbeki's call in this regard.

Of all the positions he has held over these years, it is his role as CEO of the CSIR, a national asset of considerable significance, which has probably been amongst the most demanding.

LEADING THE WAY

Asked how he has succeeded in balancing his commitment to research and management, he explains that, particularly in his present position, he sees himself as a leader. His highly competent managers deal with man-

agement, while he works with the researchers, supporting their work, making sure that he understands what they are doing, and finding ways of ensuring that the outcomes of their work find their way into practical applications.

Under Sibisi's leadership, the CSIR posted a profit of R52.4 million in the 2014/2015 financial year – despite operating in a particularly tough economic environment, and its contract research and development income increased by 12% to R1.6 billion in the same period. Projects of social and economic value in which the CSIR has been involved include the use of wave gliders to optimise fish stock surveys; a model to enhance the understanding of SA's transport sector to support decision-making; employing technology in the fight against rhino poaching; a new digital pathology database to train pathologists remotely; identification of renewable energy development zones for SA; using locally produced nanoclays for vastly enhanced plastics and a platform that will allow entrepreneurs to operate their own television stations over the mobile Internet.

Despite the demands of his working life, Sibisi commits time for national and social contributions beyond those of the CSIR. Currently, he serves on the Board of Liberty Life. He also serves on the Council of St Johns College in Johannesburg and the Board of the Mapungubwe Institute for Strategic Reflection (MISTRA), as well as the Advisory Board of the United Nations World Intellectual Property Organisation. On a more personal level, he has been a member of the Governing Board of Roedean School in Johannesburg and was a Trustee of the Hans Merensky Foundation.

Returning to where we started: Sibisi has been a keen rower and cyclist for many years; has completed the Argus cycle tour several times, and in the past few years he has completed several marathons, including the Two Oceans, the Comrades, the London and Boston Marathons. It all comes back, then, to fitness for purpose, ability to perform, and to keep running, cycling, undertaking research, translating research into valuable social and economic currency – leading until his goal is reached. While much of this has been achieved, there is no doubt that there is a good deal more to come from this remarkable scientist from Mariannhill in KwaZulu-Natal.

| HIMLA SOODYALL |

TOP THREE AWARDS

- National Order of Mapungubwe (Bronze), 2005
- President's Award National Research Foundation, 2000 – 2004
- Vice-Chancellor's Award for Research, University of the Witwatersrand, 1999

DEFINING MOMENT

Soodyall's world changed forever during her first pre-natal genetic diagnosis. "Sitting in the dark room when we still worked with autoradiographs, holding it up against the safely light... it was a case of cystic fibrosis, in a sample taken from a foetus. Both parents were carriers and had an affected child, and we saw that indeed the foetus would have cystic fibrosis as well. Here I was, looking at scientific evidence that changed my mind about the 'sins of the father' dogma that I was raised on. This is science. This is inheritance. This is a biological thing. No devil did this. And it was something I had to embrace since I felt that I was part of an instrument that would be the bringer of bad news to a family. No one trains you or counsels you on how to deal with that."

WHAT PEOPLE DO NOT KNOW

Soodyall often stays up at odd hours to watch tennis, and she always enjoys a joke, saying, "My laughing always gets me into trouble". One joke she didn't enjoy in 2005, was not a joke at all: the Presidency had some trouble getting hold of her to notify her that she had been awarded the National Order of Mapungubwe because she put the phone down on them, assuming it was a prank call.



RECOGNISED FOR ABILITY ABOVE ALL

Professor Himla Soodyall is a renowned geneticist, science communicator and advocate for respect and equality in all things. Originally from a conservative, apolitical family in Durban, Soodyall moved to Johannesburg in 1986 to pursue a Masters degree in biotechnology at Wits which led to her career in human genetics the following year.

Today, her research interests cover human population genetics, human origins, genetic susceptibility to disease and the ethical and social responsibility of science.

Soodyall spent some years in the US, at Pennsylvania State University, which had a big influence on her, both as a scientist and as an individual. She joined the South African Institute for Medical Research (SAIMR), (now transformed into the National Health Laboratory Service [NHLS]), in 1987 as a medical scientist and is also an Associate Professor in the Division of Human Genetics at the University of the Witwatersrand (Wits). Some of her activities include improving health services and policies on inherited genetic disorders, conducting genetic ancestry tests as a service to the public, expanding on population genetic research to understand the affinities of the peoples of Africa and engaging the public on important scientific issues. She is also the General Secretary of the Academy of Science of South Africa (ASSAf), a board member of Genetic Alliance South Africa, a member of the Council of Human Genome Organisation, Chairperson of the Research Development Committee at the NHLS, and a board member of Yazi (Centre for Science and Society in Africa).

With the advancement of recombinant DNA technology in the late 1980s, geneticists saw opportunities to use this technology to engineer 'superbugs' that could clean up crude oil spills, and successfully produce insulin in a Petri dish rather than in pigs. They could also use molecular genetic methods to provide insights into the roots of humanity showing that Africa, more specifically southern Africa, could be the most likely geographic region for the origin of our species.

Indeed, molecular biology was taking off, but South African researchers, despite having relatively easy access to the ancient human DNA that was in high demand the world over, were isolated from the global scientific community.

"We were hit with the academic embargo during the latter part of the apartheid era," recalls Soodyall.

"When I was working on my PhD we had no access to the computer software used to draw phylogenetic trees [diagrams showing the relationship between species based on genetic similarities]. And if you wanted to do statistical analysis on your data, the programmes were simply not available to South Africans," she says.

Soodyall only really became aware of these political hindrances to the tools of genetics research, and of the depth of genetics research itself, when she arrived at Wits to complete her MSc in biotechnology in 1987. Before that, she had been finalising her studies in microbiology and biochemistry at the former University of Durban-Westville (UDW) (now part of the University of KwaZulu-Natal) while living at home with her parents, who were largely apolitical.

It was during her early studies that Soodyall had first heard about recombinant DNA (strands and loops of DNA designed by researchers and created by 'cutting and pasting' genes and regulatory regions together), which could be used to genetically engineer living things. At the time, she didn't have access to this emerging technology, but a bottle of crude oil suspended in water, which had been sitting on the window sill of the head of department for years, sparked something within her.

"I had read a magazine article about a superbug created using recombinant DNA technology. They took genes that coded for enzymes that could break down crude oil and put them inside a bug [bacterium] using circular genetic material called plasmids. They called the result a superbug, and the intention was to produce it en masse and apply it to oil spills."

Because she had read about plasmids in the superbug article, Soodyall tried to find microorganisms containing plasmids in her own Honours project, the main objective of which was to identify microbes that could survive and thrive in crude oil.

"If I look back at my project today I don't think I even saw a plasmid," she says, "but it was so sexy at the time that I was convinced I had!"

She had also read about the artificial production of insulin, a life-saving hormone for diabetics, and decided that she'd like to explore similar biotechnologies further at Wits. Despite not having her exam results yet, but with excellent recommendations from her supervisors at UDW, she was placed on a shortlist for a biotech MSc at Wits.

"I got a call from Prof Helen Garnett, then Head of Microbiology at Wits, asking me to come up to Johannesburg to meet her." She had to be there within a day and in her words, the umbilical cord was still attached at that point, but her father encouraged her to go, so she left her home for the first time, on a bus to the City of Gold.

Once in Johannesburg, a spot opened up in the biotech MSc course. Academically, Soodyall breezed through, but there were other challenges.

"Remember, I was a person of colour so all the apartheid rules of housing segregation applied. But I had to be close to the lab, so if I stayed in Lenasia or Azaadville, where Indians were supposed to stay, how would I get there?"

Instead, she lived with a mixed-race family (white/Indian) in Mayfair for two weeks before she was able to rent accommodation in Hillbrow, then considered a "gray" area, and was able to walk to and from Wits, and later the SAIMR.

Soodyall met Prof Trefor Jenkins at the SAIMR. "I got interested in the history of the peoples of Africa through conversations with Prof Jenkins because he was a true mentor," she says. Jenkins, originally from the UK, became interested in this subject himself through conversations with renowned evolutionary biologist Prof Philip Tobias.

"We all had tea together every day and talked about all sorts of things. I had never done genetics, since I had come through the ranks of microbiology and biotechnology, but I started reading and I had to be a sponge to soak up the basics that I hadn't gotten a grounding in.

"Fortunately I was a good learner, and a hard worker, and I could apply my hands and my mind to understand the technologies."

Her efforts and smarts eventually resulted in a fellowship to Pennsylvania State University (Penn State) in the US. Says Soodyall, "I was thrown into this big league and my growth was exponential". She means as a researcher of course, but also as an individual in terms of her politics and world view.

"I had grown up neutral to politics, but at Penn State I met and engaged with black students from South Africa, who would talk politics and tell me which movies I should watch," she says. "I became more aware of political situations in the country and the foundation and dynamics of the academic boycott, even though I lived through it in the early 1980s."

"But the experience at Penn State felt like being a kid in a candy store. I was in an environment among the leaders in molecular evolutionary genetics. You could walk anywhere and speak to someone whose name you've seen on big academic papers. It was like a *dorpie* going into a big city, that's how I felt."

Knowing those scientific heavy-weights on a first-name basis on one hand inspired Soodyall to work harder than ever to live up to their expectations, but it challenged her personally on the other. "It was very different to my experience as a non-white in South Africa, and to my cultural upbringing where we had strict rules of respect and how you deal with elders irrespective of colour."

Sitting on desks, wearing shorts to work and addressing professors by their first names was all very new. But Soodyall embraced the exposure to American culture, and extended her time there to learn the basics of mitochondrial DNA analysis under Prof Mark Stoneking before finalising her PhD back at Wits.

Two years later Soodyall returned to Penn State to complete another fellowship under Stoneking, and she trained many of his anthropology students while she was there. "I was grateful for the opportunity. People took time to support me and show genuine friendship during these formative years, and having learnt from these experiences I try to do the same for others when and where I can because I wouldn't be in the position I am now given the hiccups I experienced along the way and the environment I came from." The students she engaged with at Penn State are all in top positions today.

Another thing Soodyall took from her experience at Penn State was being recognised for her work regardless of her sex or race.

"In the US people respected and included me in activities because I was a good scientist, and I hope because of my personality. It was an opportunity to find my space outside of the baggage that I grew up with. And while I have on my radar the discrepancies of the past, I never, ever allow that to come into my path."

"If I'm asked to apply for women-in-science awards, I say 'No'. I want to be recognised as a scientist, not because I am a woman. When people ask me to apply for top positions because they want to feature women of colour, I say 'No, I'm not interested'. I do not want my achievements to be associated with demographics, but rather with scholarship."

IN FAVOUR OF TRANSFORMATION

Despite her strong stance on this issue, Soodyall is in favour of transformation among scientists, which is part of her mandate as General Secretary of ASSAf. But real transformation and equality, she says, means being truly recognised for one's abilities above all, regardless of race or sex. "Many things contribute towards transformation and we should endeavour to do this holistically, with an understanding of the past and factors that contribute to inequity."

Soodyall also knows that it's not only women and people of colour who are at a disadvantage in South Africa, but that those suffering with con-

genital birth defects and rare diseases, roughly 15% of the population, are too. She uses her position at ASSAf and as a board member of the Genetic Alliance South Africa to act as a voice for these marginalised members of society, and to make evidence-based recommendations on related national health policies.

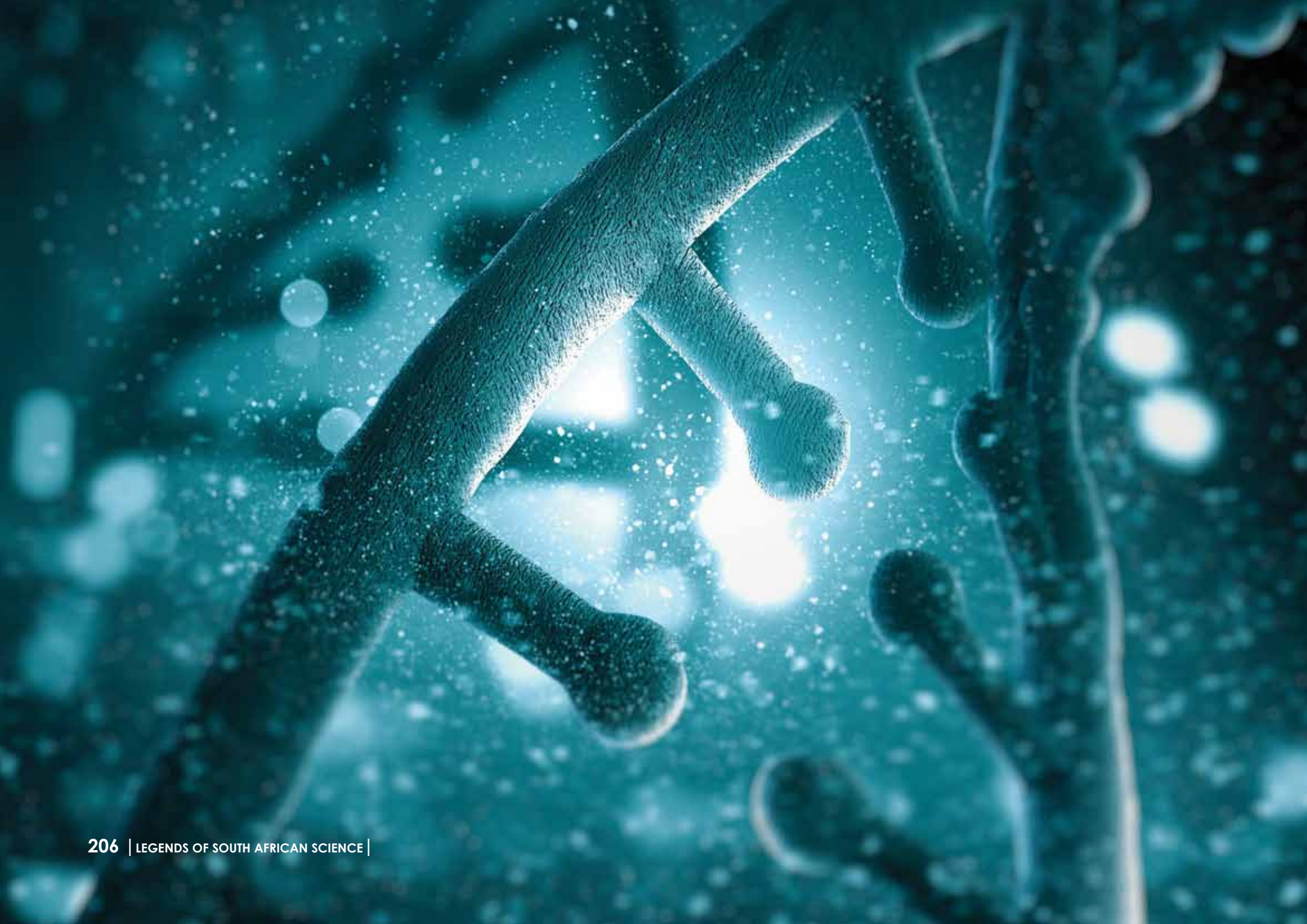
This work underlines Soodyall's academic interest in the genetic susceptibility of people to diseases, as well as her advocacy that science should be ethically and socially responsible, and that scientists should engage with the public at all levels as well as with government.

Soodyall herself often promotes and facilitates public engagement with science, particularly through the work she is most known for in the public eye: genetic ancestry testing.

"I strongly believe that in the same way we can make time to go to individuals requesting them to participate in our studies and get informed consent, we have a responsibility as scientists to make time to share the results with the people who make us successful as scientists," she explains. "When we studied the San in the Kalahari, we went back to celebrate Heritage Day with one of the groups we worked with in order to try and bring back the science buzz to the community level."

Although that was some years ago, to this day Soodyall gets calls from individuals who would like to trace their ancestry. "One person having an ancestry test becomes a conversation at a dinner party, and suddenly people are talking about it and more people who have access to resources can do it," she says. "That shows the cascade of how to stimulate interest in the sciences."

One of the simplest metaphors Soodyall uses to explain genetic ancestry and evolution to lay people, is that we are all leaves on the branches of the tree of life, which has a single common trunk. "Our leaf may be placed on a different branch, but we're still part of the same tree. It shows unity and togetherness," says Soodyall.



Despite this clear message that all humans are the same species and descend from a common ancestor, some, including other scientists, have labelled Soodyall's work as racist science. They argue that genetic ancestry talks about identity, which might be used, for example, to show someone is a direct descendant of a particular tribe that occupied a particular piece of land before Europeans arrived. Soodyall has however always insisted that genetic tests have nothing to say about a person's identity, and she fervently advocates against discrimination based on race.

But changing people's opinions about science must always be done from a point of respect, says Soodyall. This is particularly true for sciences that deal with human origins, since many people have their own beliefs shaped by religion and experience.

"I also have my own beliefs, and I don't force them on anybody else. But if I'm asked, I will explain how my position on issues changed and adapted as I began to understand evolution," she says. "People are able to make sense of the world for themselves, so it is only up to me to provide information we have at hand, and whatever they decide to believe in is fine with me."

This rings true within Soodyall's own family – her convictions don't always align with their traditional beliefs, but she says it's important to find a bal-

ance between what one feels strongly about and what one thinks is the right thing to do. "For example, when my mother died I did the rites and rituals because that's what she would've wanted. The most important thing is respect. You've got to have respect for all individuals, all beliefs."

Something that particularly infuriates Soodyall, is the lack of respect many people today show towards their parents. Prior to her passing, Soodyall had cared for her mother during an illness, despite having to travel often as part of her responsibilities as principal investigator on a National Geographic Society project.

"For me it was a privilege and an honour to be able to give back to my mum for the sacrifices she had made in her life and career to give us the opportunity to study," she says, adding that parents unreservedly take care of their children until they 'break the umbilical cord', as she had done when she first moved to Johannesburg nearly 30 years ago.

And looking forward ten or 20 years from now, Soodyall says, "If I were to reflect down the line on what made me come to work every day, it would be a kind of buzz; that buzz of having the fluidity between what is your heart's calling and how that blends into engagement with people around you".

| PIETER STREICHER STEYN |

TOP THREE AWARDS

- National Order of Mapungubwe (Silver), 2011
- Academy of Science of South Africa Science-for-Society Gold Medal, 2007
- Gold Medal of the South African Chemical Institute, 1987

DEFINING MOMENT

Joining the National Chemical Research Laboratory of the CSIR in 1964. "This led to my career in biologically active substances, particularly mycotoxins."

WHAT PEOPLE DO NOT KNOW

Steyn has a potent toxigenic fungus, *Aspergillus steynii*, producer of the ochratoxins, a group of nephrotoxins, named after him. He also met the Emperor of Japan during the 125th anniversary of the Chemical Society of Japan (2003).



A MATTER OF CHEMISTRY

Chemistry is not always viewed as being relevant to society. In fact, a recent report by the Royal Society of Chemistry found that the public doesn't really care about chemistry and struggles to identify applications that are of personal relevance.

While other sciences are seen as more exciting and interesting, more 'complicated' sciences, such as chemistry, are largely taken for granted. However, chemistry is central to all types of science. Without it, other fields of inquiry such as molecular biology and environmental science would not be possible. One of the salient missions of chemistry is the creation of innovative substances that can improve the quality of life around the globe and contribute to the national and international economy.

Regardless of its importance, this dispassionate view of chemistry is prevalent and makes it particularly important to report on and support scientists who are making advances in the field of chemistry in ways that are relevant.

One such chemist is Professor Pieter Streicher Steyn, a recent retiree as Senior Director of Research from the Division of Research Development at Stellenbosch University (SU). His achievements in and contributions towards the chemistry and biosynthesis of mycotoxins have won him many accolades.

Steyn was born in 1940 in the agricultural town of Vryburg in the North West province of South Africa. At the local high school, he was inspired to pursue science by his teachers. "We had very good teachers," Steyn recalled. "Our science teacher at the time had a Masters in chemistry and a Masters in mathematics." He followed in the footsteps of his teachers and moved to SU. There he received his BSc in chemistry and geology in 1959, followed by an MSc from SU and later a PhD from the University of South Africa (Unisa).

His MSc with Prof Chris Garbers in Stellenbosch and his PhD with Prof Cedric Holzapfel at the Council for Scientific and Industrial Research (CSIR), Pretoria, formed the foundation for his career in organic chemistry and special-

ising in the chemistry of natural products, such as mycotoxins. Mycotoxins are toxic secondary metabolites of fungi. Not all secondary metabolites of fungi are classified as mycotoxins; a famous example is penicillin. Penicillin is an antibiotic that *Penicillium* fungi produce to kill off competing bacteria from the surrounding area that it is trying to colonise, a clear benefit to the penicillin fungus. However because penicillin is toxic to bacteria, it is considered an antibiotic rather than a mycotoxin. Steyn describes mycotoxins as "by-chance metabolites" that have vastly different chemical structures and biological activities. It is still not understood if fungi produce mycotoxins to protect themselves or if there is some other reason.

A mycotoxin is a chemical compound of a small molecular weight that is toxic to animals, including humans. The oldest observations of mycotoxicoses (diseases caused by mycotoxin poisoning) were in the Middle Ages in Europe. These 'epidemics' were described as divine punishment or bewitchment, where victims described the burning sensation in their limbs as Holy Fire or St Anthony's Fire. This was later linked to mycotoxins produced by ergot fungi, a group of fungi of the genus *Claviceps*. Contaminated bread or grain has been linked to the outbreak of similar symptoms up to the present day. Rye flour contaminated by *Claviceps purpurea* is thought to be the cause of an outbreak in France in 944 AD which killed 40 000 people. Mycotoxins may also have driven the Salem witch trials in the US, though this is contested in literature. While the scale of outbreaks has shrunk and instances have become more and more rare, the more subtle effects of mycotoxins on humans and other animals have, until recently, been largely neglected. In the 1960s, a mysterious disease called turkey-X disease killed over 100 000 young turkeys in Britain. It was soon linked to mycotoxins of the fungus *Aspergillus flavus* which had been contaminating peanuts imported from Brazil. The liver toxin was subsequently named aflatoxin to reflect its connection to *A. flavus*.

The discovery of aflatoxins led to a renewal of interest in mycotoxins as potential hazards present in food and feed that may cause illness and death in humans and livestock. Current research has identified more than 300 mycotoxins, each of which has its own host of deleterious effects. The problems associated with the ingestion of mycotoxins vary, just like the in-

gestion of any poison would vary depending on the concentration and composition of that poison, as well as the size and body mass of the victim. Mycotoxins have been known to cause cancer, change genetic material, disturb reproduction, and hinder development of a foetus or embryo. They can also cause haemorrhaging, liver and kidney problems, immunosuppression, skin damage, and nervous system damage. In the case of aflatoxins, not only do they affect turkeys, but they have also been classified as a human carcinogen linked to primary liver cancer. This link led to a series of global studies that correlated prevalence of liver cancer to the contamination of foodstuffs by aflatoxins. This research was particularly relevant to southern Africa since the highest incidence of primary liver cancer in the world occurs in some areas of Mozambique.

RENEWED INTEREST

The renewed interest in mycotoxins in the 1960s put Steyn's research at the forefront of chemistry in terms of importance and application. His research contributed towards the development of sophisticated methods of detection in order to accurately monitor their presence and to develop regulatory policies to reduce their impact. Steyn continues to work closely with the maize industry to ensure that safe maize is supplied to consumers, food and animal feed industries, and export markets. He explained that, although mycotoxin contamination of South African commercial maize is low, the quality of maize produced by subsistence maize farmers in poor rural areas is more variable and often contaminated with high levels of mycotoxins. "Unfortunately," Steyn said, "when they process the maize, they sell the best and keep the worst to use for themselves." However, strict regulation and the development of educational programmes could significantly reduce the impact of mycotoxins on the African continent.

As with many scientific endeavours, half the battle is understanding the subject. At the CSIR, where he worked from 1964 to 1993, Steyn's dedicated research team was involved in the extraction, isolation and characterisation of several new mycotoxins from mouldered material. Although "isolation and characterisation" of a mycotoxin might sound simple, it's not. Mycotoxins must first be extracted with a solvent. This is followed by

a "cleaning" step involving liquid/liquid partition and column separations to remove residual chemicals from the extract. Because mycotoxins are so different, these methods differ drastically depending on the structure, polarity and stability of the mycotoxins. However, innovations in methods, materials and technology have made this process easier. "What previously took us years to accomplish can now be done almost overnight. In the case of structural elucidation, very high field nuclear magnetic resonance (NMR) spectroscopy and single crystal X-ray crystallography made a significant difference." While this part is easier now, some mycotoxins are still difficult to isolate. "I spent a good part of my life trying to isolate a unique toxin from *Stenocarpella maydis*. Now, 30 years later, researchers still have been unable to isolate the significant toxins from the moulded material."

Much of this work came from Steyn's time at the CSIR. "Some of the best research equipment in the world was available to researchers at the CSIR. We were leaders in the field of mycotoxin chemistry and biosynthesis and we enjoyed collaboration with research groups from all over the world."

Steyn's research group made significant contributions to developing the principles of biosynthetic architecture of secondary metabolites by applying stable isotope labelling experiments and very high field NMR spectroscopy to establish the labelling patterns and the structures of some fungal metabolites.

Once mycotoxins have been isolated and characterised, tests and regulations for food safety can then be designed and implemented. "You must be able to isolate the toxin in a very pure form and then develop an analytical method to test its presence in foods and feeds." There is strict legislation globally that governs what level of mycotoxin contamination is allowed for various products. The technology for detecting mycotoxins has also changed drastically. In the past, thin layer chromatography was used. Now more accurate techniques, called HPLC and UPLC/MS, are used. Researchers can now detect toxins in parts per billion, an incredibly high resolution.

The ease of international collaboration on this topic is partly due to the worldwide occurrence of the mycotoxins themselves. "What's nice about

working with mycotoxins is that they are internationally distributed thereby leading to international collaboration, whereas if you work with plant toxins, those plants might only occur in a certain area."

Steyn was the first person from Africa to be elected President of the International Union of Pure and Applied Chemistry (IUPAC), Research Triangle Park, North Carolina, USA. He was also elected as President of the International Association of Cereal Science and Technology (ICC), Vienna, Austria. This enabled him to play a leadership role in the international science community.

In his new roles, he moved away from practising chemistry and worked more for enabling collaboration. While he recognises the value of his role at facilitating international collaboration, he sometimes regrets his departure from lab work.

Steyn's contributions to science have been recognised by way of numerous awards. He also received an honorary PhD from Unisa in 2010 in recognition of his research contributions in chemistry and for services to the international scientific fraternity as President of IUPAC and President of ICC.

After a busy career, Steyn is enjoying his retirement. He has been able to travel more with his wife, Margot, and to spend more time indulging in the little pleasures of life – following current development in finance and politics, reading *The Economist*, and going to the gym more regularly.

However, retirement has not meant a complete departure from his participation in science. He still coordinates the mycotoxin research programme of the Maize Trust on behalf of the maize industry, and in addition he consults for Innovus, the Office of Technology Transfer at Stellenbosch University. He also serves as an Associate Editor for the *South African Journal of Science*, assists researchers with NRF rating applications, and reviews the occasional paper. "I am still not totally relaxed," he says, "it still feels like there are things to get done."

He is excited about the potential in South African research and has this advice for youngsters: "Create a clear vision of your future, work hard and follow your dreams".



| PAUL VAN HELDEN |

TOP THREE AWARDS

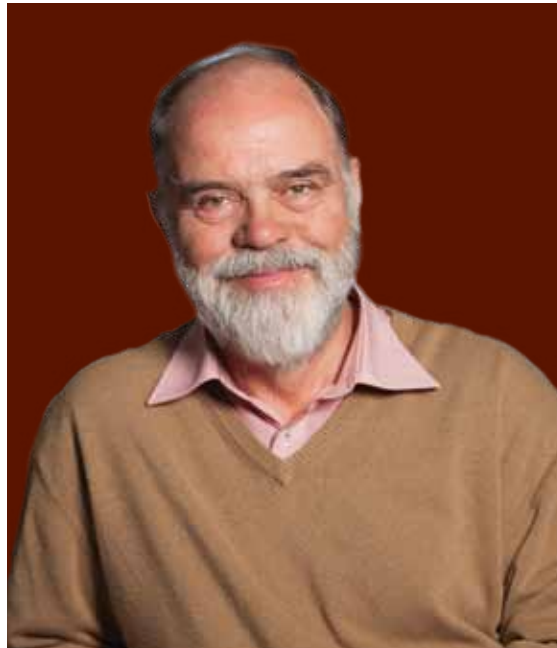
- ASSAf Science-for-Society Gold Medal, 2009
- NSTF Award for Outstanding Contribution to Science, Engineering and Technology, 2004
- Gold Medal Award from the South African Society for Biochemistry and Molecular Biology, 2001

DEFINING MOMENT

In 2008, *Nature* published a major paper that showed that identical twins show DNA methylation differences, confirming the results of a study that I had undertaken with a Masters student, Mark Bedford, in 1988, and which had been rejected by *Nature*. Imagine my thoughts and emotions when I saw this paper! I learned a great deal from this experience. For instance, that it is very difficult to be ahead of one's time and to challenge dogma. It made me very determined to challenge dogma and stick to my findings, which I have regularly done since then in my TB career.

WHAT PEOPLE DO NOT KNOW

I am a lifetime member of the Botanical Society and an honorary ranger with South Africa's National Parks service.



CHALLENGING THE TB DOGMAS

Starting out as a basic scientist, Paul van Helden has had a great impact on changing our understanding of tuberculosis (TB) and TB treatment in South Africa.

Starting in the late 1980s, he pioneered the use of molecular technologies to study the country's tuberculosis epidemic. Today, with drug resistance a growing problem, the country's health care system routinely uses the technologies he helped pioneer to diagnose TB in the clinic.

Although a nature conservation buff, Van Helden has spent the majority of his career at Stellenbosch University's (SU) medical campus in Tygerberg. "What I've tried to do is create a research environment that ranges from the basic to the applied in TB, with a focus on making a difference," he says.

Growing up in Bergvliet, in the southern suburbs of Cape Town, Van Helden was fascinated by nature. At the age of 13 he joined the Botanical Society of South Africa. As a pre-teenager his favourite books were biographies of famous scientists like Marie and Pierre Curie. To his non-academic parents their son's deep interest in science was a bit of a mystery. Yet, they were pleased that he wanted to study for a university degree, hoping it would set him on the track to a good job.

Van Helden did not find his undergraduate studies at the University of Cape Town particularly fulfilling. He felt constrained by the course content, which at the time he thought had little apparent connection to usefulness. By the end of his first degree, he felt disillusioned with academic life. He didn't believe the course had taught him anything practical, or conferred any useful skills.

Nevertheless, he stayed on for an Honours degree, reasoning that a Bachelor's degree wasn't enough to give him an edge in the job market. As it turned out, the Honours course in biochemistry suited him far better, since it was his first chance at doing a research project. "I was far happier," he recalls. But his sights – and those of his parents – were still firmly set on getting a good job at the end of the course.

After his Honours in 1974, Van Helden was offered a job as a chemist at the City of Cape Town's sewage plant in Athlone. His parents approved, but a split-second decision on the drive home from the job interview changed things. Mindful, perhaps, of his childhood dream of becoming a scientist, he took the UCT turnoff and went to see his Professor, Claus van Holt. Van Helden asked him for advice: Should he take the job?

The Professor made a counter-offer: If Van Helden wanted to, he could have a PhD studentship in the Biochemistry Department. That way, he could see whether he liked research – and if not, there would be other jobs after his PhD. Van Helden's parents were distraught at the prospect of their son turning down a well-paying job. But his mind was made up. He would accept the offer.

EARLY ACADEMIC LIFE

For his PhD, Van Helden studied protein sequencing. This technology was established, but rare in the mid-1970s. It was very basic research, and in truth Van Helden finally found it a bit boring. But his supervisor advised him to be patient. "I remember him saying that part of doing science is having the tenacity to hang in there, to get the job done. He told me that your PhD is your passport, your certificate of training. After that you can choose what you want to do."

Van Helden received his PhD in 1978. Over the next two years he worked as a Senior Professional Officer in the Department of Medical Physiology and Biochemistry at SU's medical school and expanding on his PhD work and moving it to a new field, he worked on chromatin – a complex of DNA and proteins that forms chromosomes – in muscle cells. But the field of molecular biology was developing rapidly, and Van Helden felt that he needed to be exposed to new ways of doing things.

He left South Africa in 1981 to take up a two-year postdoctoral fellowship at the Roche Institute of Molecular Biology in New Jersey, USA. The purpose of his trip was to be exposed to different ways of running a lab and research group and to learn 'recombinant DNA technology'. At the time,

only a couple of people knew how to do it in South Africa, and they, too, had learnt it abroad.

Van Helden returned to SU in 1983, where he continued to work on muscle cell biology. But soon his interest started shifting towards DNA structure and epigenetics, the study of how different parts of the genome can be switched on or off, by DNA structural change or methylation changes. This happens naturally as our bodies develop and age, but can also be caused by external factors like our diet or environment. It plays a key role in disease like cancer.

He also pondered how the molecular biology techniques he had learnt overseas could be applied in South Africa to improve treatment outcomes for patients. A big advance in the field had happened in 1984 when California-based chemist, Kary Mullis, invented the polymerase chain reaction (PCR) technique. This is a type of 'molecular photocopying' that allows scientists to make millions of copies of DNA samples, making them far easier to study. Mullis received the Nobel Prize for it in 1993.

Today, PCR can be done in minutes using specialised equipment, but in the late 80s the technology involved a lot of hard work. Van Helden and his colleagues got into it on a manual basis, using water baths and stop-watches. It was too labour-intensive to be useful, so with the help of two technicians, Van Helden's group designed and built Africa's first automated PCR instrument out of four hair dryers. The instrument vastly enhanced his team's ability to do PCR. So he began looking for an area of research where he could apply the technology to health problems facing his country.

MOVING TO TB

His attention quickly turned to tuberculosis. The disease was a big problem in South Africa, especially in poor communities and among mineworkers. However, the way that TB was diagnosed had not kept up with advances in science.

Diagnosis was a lengthy process involving culturing bacterial cells from the spit of a patient. PCR technology could speed it up significantly. But the

idea of using molecular science for such purposes was almost unheard of in a low-resource setting such as South Africa's public health system.

Van Helden and one student started applying molecular techniques to investigate how well these technologies could be applied to TB diagnosis and to gain new insights into the disease. Early successes, coupled with his appointment as Head of the Division of Molecular Biology and Human Genetics (then Medical Biochemistry) and also Director of the Medical research Council (MRC) Centre for Molecular and Cellular Biology in 1992, allowed him to devote more inputs to TB and persuade colleagues and co-workers to join his TB effort and start their own projects. International grant support followed, which by 2004, had established the team well enough to allow him, together with colleague, Professor Valerie Mizrahi, to be given a grant that established the Department of Science and Technology/National Research Foundation (DST/NRF) Centre of Excellence for Biomedical TB Research, where he is now Director.

But in those early days of TB research there was some resistance to new technology. The idea of using molecular biology to study and diagnose TB in the country was thought by many to be "too expensive and not practical", Van Helden says.

Van Helden speculates that part of the problem was that early results started to challenge long-held beliefs and dogmas dear to many. However, he and his colleagues used such techniques to great effect. For example, they found that contrary to common belief, patients turning up with TB after already having been treated and declared free from the disease once before were often re-infected with a different strain: In other words, it was not a case of relapse.

These results were published in a seminal paper in the *New England Medical Journal* in 1999. The paper kick-started a whole new field of study into TB re-infection, and changed the thinking about how to conduct and interpret drug trials in the field. His team's work in antibiotic resistance has also been instrumental in pushing for routine testing and modification of therapy.

Over the years since then, Van Helden and his colleagues have built up an impressive body of publications from the SU medical school.

He was also instrumental in giving a boost to Professor Andreas Diacon, a South African entrepreneur who runs clinical trials for TB drugs. Diacon's work has resulted in new antibiotics being trialled in conjunction with Van Helden's centre of excellence and made available for treating TB. "I'm very proud of being a part of that," he says.

In 2009, the scientific publishing company Thomson Reuters rated Paul van Helden the fourth most impactful TB research researcher in the world. "That to me was my crowning achievement," he says. He shares such accolades with his colleagues, since he believes that surrounding himself with a great team has been the key to his success. He enjoys teaching students, and regards them as his extended family. "I still feel a thrill every time one of them publishes a paper."

He has worked with and for the MRC under every single president of MRC, and at Stellenbosch under every medical dean except the first. Over his career Van Helden has received a number of awards and prizes. But most of all he treasures the memory of the surprise party thrown for him by his centre and department for his 60th birthday!

LOOKING AHEAD

When he retires he plans to continue to be involved in TB research part time, and spend the rest of his time on nature conservation. As lifetime member of the Botanical Society and an honorary ranger with South Africa's National Parks, he has to serve the parks by providing a minimum of 100 hours service every year. He currently clocks well over 400 hours per year.

His wife is also a Professor in his centre and also an honorary ranger. Together, they have worked on projects like tracking down the original 100 markers placed out in Table Mountain National Park in 1966 to mark out

botanical plots. These are now being used by the South African Environmental Observation Network and students to investigate changes in vegetation and climate. He also goes to the Kruger National Park at least once a year as part of a project to study TB in wildlife – a growing concern in South Africa's wildlife reserves.

Today, molecular diagnostics is no longer in the fantasy realm of South Africa's health care system. In 2011, South Africa's health minister announced that an automated PCR machine called GeneXpert would become the first-line test for TB in the country. Although Van Helden does not want to credit himself for this change in policy, he likes to believe that his early work led to some of the changes seen recently in the way TB is addressed nationally.

There are also many more scientists working on TB today than when he started out. But TB still has far fewer people working on it than HIV – something he thinks is "disgusting" given that the former is curable. The two diseases are linked in South Africa, where immune systems weakened by HIV are more vulnerable to TB infection. Van Helden remains committed to study only TB. "If you don't understand them separately, then you will have difficulty working on two."

He is highly critical of the way medical, veterinary and biological science is hamstrung by excessive regulation and red tape. "The science environment in South Africa has changed in some ways for the worse, by creating overly strict regulation and monitoring. We are being over-governed and over-regulated, spending more time trying to comply with the rules, writing reports and chasing grants."

However, to Van Helden, who was an active scientist in South Africa during the academic boycotts of the apartheid era, the opportunities given to students today to travel and study all over the world are enviable. It also spells good news for the future. "We are now part of a global network in a way that was impossible in the first half of my career. That's enormously exciting and encouraging," he says.

| BRIAN VAN WILGEN |

TOP THREE AWARDS

- National Science and Technology Forum's annual award for an outstanding individual contribution to science, engineering and technology, 2010
- South African National Parks' annual award for corporate contributions to conservation by an individual, 2010
- Science-for-Society Gold Medal Award from the Academy of Science of South Africa, 2016

DEFINING MOMENT

Learning in late 1970 that there was a degree course in forestry, with a major in applied ecology (called "nature conservation" at the time). It was right up my street and gave me the opportunity I needed to pursue a career in that direction.

WHAT PEOPLE DO NOT KNOW

I am a keen collector of natural history books, postage stamps, and art works; I am an avid birder, and my life list is approaching 1500 species. I am a qualified pilot, and a qualified scuba diver. I dislike eating liver, swimming in cold water, and crowded and noisy spaces. And I never met Nelson Mandela – a great disappointment.



THE FIRE MAN

Brian van Wilgen had a dream as a child: To become a game ranger and spend his life amid the awesome wildlife that inhabits South Africa's national parks. The rhinoceros, the buffalo, the lion, and the elephant: None of them prowled the marshlands of Milnerton, the suburb of Cape Town where he grew up. But their images would grace the back of his breakfast cereal packets, and from a young age Van Wilgen was hooked.

Van Wilgen never became a game ranger. Yet, his illustrious career as an environmental scientist studying the effects of fire on ecosystems has brought him close to his childhood dream. At one point he and his family spent several months in the Kruger National Park – a time he describes as one of the most satisfying of his academic life.

But the bulk of his life's work – as well as his time – has focused around the Cape fynbos ecosystem. The shrublands surrounding Cape Town make up the smallest of the world's six floral kingdoms. It is one of the world's most biodiverse regions, and also among the most vulnerable. Its small size makes it especially sensitive to alien species invasion. The iconic slopes of Table Mountain is ground zero for a long-running war between the Australian wattles and European pines and the indigenous slow-growing proteas, ericas and silver trees.

Van Wilgen is a decorated general of this war. In 1995, he helped to start Working for Water, a government-funded programme mobilising poor communities in alien vegetation clearing activities. The programme has enjoyed sustained support. It creates jobs while improving water security by getting rid of thirsty invasive plants. Since its inception, the programme has cleared more than one million hectares of invasive plants, providing jobs for 20 000 people from marginalised communities.

His job is far from done, however. "Alien vegetation remains a threat in this country. We have to become more effective at managing the problem." South Africa is running out of water, and alien species management is vital to protect the resources that remain. "If we allow the fynbos water catchment areas to be covered by pine forest then the city will run out of water completely," he says.

KINDLING A PASSION

Young Van Wilgen may have dreamt of being a game ranger. Instead, he became a scientist. It happened by accident, he says. "By the time I finished high school there were no courses to study to become a game ranger like there are today. There was a chance you could work in game reserves if you studied to be a vet. But my matric results weren't good enough for that, and also I would have had to spend five years in Pretoria."

Instead, he enrolled on a new course being offered by the nearby Stellenbosch University: A Bachelor of Science in Forestry and Nature Conservation. He was one of the first students to take the course, and after graduating he took up a post at the nearby Jonkershoek Forestry Research Centre, which was expanding its ecology research programme. Here he met Fred Kruger from the South African Forestry Research Institute. Kruger, not much older than Van Wilgen, nevertheless became mentor to the latter. Together, they began working on models to predict wildfires – a necessary regular occurrence for the natural environment around them, but also potentially ruinous for landowners.

At that time – the late 1970s and early 1980s – the Department of Forestry was the second-largest owner of conservation land in South Africa, after South African National Parks. These included fynbos and grassland mountain catchments in the Cape and the Drakensberg, almost all of South Africa's indigenous forests, and large coastal areas set aside to protect local flora and fauna. Research on the ecology and management of these areas, therefore, was a priority, and the department funded Van Wilgen to complete both his Masters and his PhD while stationed at Jonkershoek.

As part of his training, Van Wilgen spent six months in the United States to learn about models for predicting fire behaviour. This gave him a breadth of knowledge that he could use on his return to apply to a more varied range of vegetation types. "Until then all my work had been on fynbos, but after my US visit I could branch out." Soon after his return he travelled to the Drakensberg region north-west of Durban to train people working there in conservation techniques.

By this time he had met and married his wife, Jane. The two would have two children: Nicola born in 1984 and Lawrence, born in 1988. A keen waterman, Van Wilgen participated in varsity aquatic sports. He was on the college team for spear fishing, scuba diving and underwater hockey – a game played in pools with goggles, sticks and a heavy puck.

MOVING ON

Van Wilgen worked 15 years in the South African Department of Forestry in a number of management and research roles. However, as South Africa's democratic era dawned in 1990, the forestry department was broken up. Its plantations were privatised and its research unit – of which Van Wilgen was a key part – was moved to the Council for Scientific and Industrial Research (CSIR).

Life at the CSIR brought fresh challenges with pressure to secure contracts to fund research.

With Working for Water, Van Wilgen struck gold. He started as Programme Manager for the initiative, and was later its scientific adviser. The job creation aspect of the alien vegetation clearing initiative let it ultimately grow to a billion-Rand budget. Without the job-creation and poverty-relief aspects, such an environmental management programme would realistically only have attracted a minute fraction of its current funding. A small proportion of the Working for Water funding was dedicated to research, and remains so to this day.

For all its successes, however, Van Wilgen believes there are shortcomings with the Working for Water programme that have to be rectified if it is to achieve its alien vegetation eradication purpose. The imperative to maximise employment among the rural poor diverts funding from more expensive, but indispensable aspects such as planning and monitoring. "The programme is between a rock and a hard place" says Van Wilgen. "The lack of capacity to cover all aspects of professional management has resulted in widespread inefficiencies which are difficult to avoid."

"Although it is difficult for conservationists to swallow, we may have to sacrifice some areas to save others" Van Wilgen says. "You can't clear

alien vegetation well by just removing them in an uncoordinated way. The plants spread faster than you can pull them out. We must identify the areas that we can save, and focus there. If we are to succeed, we must employ fewer people, but train them properly, equip them better, and pay them more."

LIVING THE DREAM

Van Wilgen did get an opportunity to live his childhood dream when the Kruger National Park advertised for the head of scientific services in the park. It was shortly after his move to the CSIR, and he applied despite the deadline for applications having already passed. To his surprise, he was offered the job. But in the end he didn't take it.

"There were many reasons for that decision," he says. "My daughter was about to go to high school. She would have had to be sent to boarding school." There was also the fact that the Lowveld area where they would live was in the middle of an endemic malaria area. Full-time life in the bush would, the family agreed, not suit them at that time.

Van Wilgen managed to secure a slice of the job offered to him, however. He asked if he could join the Kruger National Park's science team and help them study the effects of fire on the bush and wildlife. The park acquiesced, and Van Wilgen managed to persuade the CSIR to give him a three-month sabbatical. During this time the whole family relocated to the Kruger, and Van Wilgen remembers it as a particularly productive time of his academic life.

There were heaps of interesting data collected in the Kruger Park over the years, much of which could be used to determine the best way of managing the bushveld when it comes to fires. The park had collected maps of burnt areas ranging as far back as the 1940s. Over the years, the park's approach to fire management changed several times, and policies included fire prevention and suppression, deliberate burning, or simply allowing nature to take its course by allowing fires ignited by lightning strikes to continue burning.

When Van Wilgen and his colleagues looked at the actual outcomes of these policies, they were surprised at what they found. The proportion of



the park that burnt every year did not change when management policies changed. Rather, they found, fire activity could be easily predicted simply by looking at the rainfall amounts in the previous two years.

In other words, there was little humans could do in terms of managed burns to change overall wildfire patterns in the Kruger National Park, which receives over 1.5 million visitors each year. Van Wilgen kept the collaboration going with the park after his sabbatical, returning at least once a year – a nod to his childhood dream.

LATER LIFE AND ACCOLADES

Van Wilgen also travelled farther afield. His wildfire research activities took him, for example, to areas as varied as the island of Reunion and Perth in Australia, or Argentina and Spain. In 2004, he was appointed as a Fellow of the CSIR in recognition of his contributions and leadership in science and technology. In 2010, he received the National Science and Technology Foundation's annual award for outstanding contributions to science, technology and innovation. That year he also was given the South African National Parks' annual 'Kudu' award for his contributions to conservation.

In 2011, he was elected a Member of the Academy of Science of South Africa. Three years later, in 2014, he became – for the first time of his life – a full-time university employee. The CSIR encourages its staff to retire at 60. But Van Wilgen was not ready to put up his binoculars quite yet and accepted a professorship at Stellenbosch University's Centre for Invasion Biology.

University life suits him, he says. There are no sales targets and deadlines in the same way as at the CSIR. He enjoys the teaching aspect of the job. Of course, he'd taught courses in the past, and done research. But the epithet of full-time 'academic' had always seemed to him incongruous with his positions. And it still does, to some extent.

"I'm not sure I'm a true academic. What I liked at the start of my career was to take the results of a study and use them to solve a problem in the real world." He still prefers to see his work make a practical difference rather than earn academic accolades – although to be fair, his work has done both.

| BRIAN WARNER |

TOP THREE AWARDS

- John FW Herschel Medal, Royal Society of South Africa, 1988
- ASSAf Science-for-Society Gold Medal, 2004
- Fellowship of Balliol College, Oxford, 1965 – 67

DEFINING MOMENT

In physics class at my grammar school in England I realised one day that I didn't know in which century Isaac Newton was born. I looked him up in my dad's encyclopaedia. That got me permanently interested in the history of science.

WHAT PEOPLE DO NOT KNOW

I collect picture postcards that are 100 years old or more of the area I grew up in and of the Cape Peninsula.



ADDING THE SALT TO THE SKIES

Spending over half a century peering out into the cosmos has not made Brian Warner feel small. "I often get asked if I am overawed by the size of the universe. I am not," says the Cape Town-based astronomy Professor. After all, he is as big compared to an atomic nucleus as the universe is to him – a perspective that he finds comforting. "I'm right in the middle," he says, with a smile.

Warner has had a long and illustrious career in optical astronomy, first in the United Kingdom, then in the United States, before finally settling in South Africa. He was the first Head of the Astronomy Department at the University of Cape Town (UCT), and has watched it grow under his influence.

Today, South Africa's ambitions in astronomy are huge. It hosts the Southern African Large Telescope (SALT), which Warner named. It happened during one of his monthly lunches with the Director of the Cape Town observatory, Robert Stobie.

"Bob said to me that he'd gotten the money for the big telescope we had talked about, but that he needed a name for it. I thought for a second, and then reached out for the salt pot on the table. This will do, I said: the Southern African Large Telescope."

However, greater things are still to come with the country chosen as the central host of the enormous Square Kilometre Array (SKA) radio telescope. Projects such as SALT and the SKA would have been difficult to manage, had it not been for the people trained and the experience built up at what remains the country's only pure astronomy department at UCT.

EARLY LIFE AND EDUCATION

Brian Warner was born in Crawley Down in Sussex, England in 1939, a few months before the outbreak of World War II. His father was a gardener on a country estate, and his mother was a housewife and charwoman. They were not wealthy people, and had decided to only have one child in order to give him every opportunity they could offer.

When the male teachers in his local school went off to war, Warner was sent to a school in a neighbouring village with women teachers. They were good, he remembers. He also owes them his good fortune. When the time came for him to sit his '11+' exams to see if he would be selected to a good grammar school, Warner had a bad day. "I failed in mathematics," he remembers. Fortunately, there were vacancies at the grammar school in the end, and the school inspector asked Warner's headmistress whether she knew of a child whom she thought should have passed the exam, but hadn't. She told the inspector: Brian Warner.

Warner developed a fascination with science while at grammar school. He'd inherited a natural curiosity from his father. Warner senior had been taken out of school at 14 – but in general knowledge and plain ingenuity, his intellect surpassed that of his son, in the latter's estimation. Young Warner's passion was natural history. He might have become an archaeologist or a palaeontologist, but he could not abide cutting up animals in zoology class, and that meant that he was not allowed to do botany either.

However, as a teenager, Warner picked up an amateur interest in astronomy. The famous British astronomer Sir Patrick Moore lived just on the other side of the town from Warner. He and his friends became known as "Patrick's apprentices", due to the fact that they would go to Moore's house and use his telescope.

Warner went to study for his undergraduate degree at University College London (UCL). It was the only university in England at the time that would allow students to take astronomy as a first degree. Backed by a small scholarship (£5 per week), he was able to pay for food and lodging as well as the odd train ticket to visit his parents on weekends. Warner supplied his mother with money for the Sunday roast, a household treat.

Astronomy "was not an easy degree," Warner recalls. The first two years he had to do all the mathematics that the physicists did, plus all the physics that the chemistry students did. On top of that, he had to take courses on astronomy and carry out practical work at the observatory in Mill Hill, which amounted to 41 contact hours per week. Regardless, he found time

to work on his own ideas. His first scientific articles, on observations of Moon craters, were published in the *Journal of the British Astronomical Association* in the 1950s. In 1960, three weeks before his final undergraduate exams, he published his first paper in the *Monthly Notices* of the Royal Astronomical Society.

Exams were easy for Warner, who possessed an almost super-human short-term memory. In lectures, he would take notes, and later he would be able to write out in full what the lecturers had said. He quoted his lecturers *verbatim* in his exam answers, and thus had time to answer all six or seven of the exam questions in full (students were only required to answer five). As a result, he got ridiculous scores like 120%, and afterwards astronomy at UCL changed its examinations so that students were not allowed to answer more than five questions, even if they could.

Warner went on to do a PhD at UCL in astronomical spectroscopy under Roy Garstang. The method analyses the light emitted by astronomical bodies by studying their optical spectrum. This can reveal many things, including the chemical composition of the light-emitting body. Garstang had used spectroscopy to study the atmosphere of stars while working in the USA.

Warner travelled to Pretoria, where the British-owned Radcliffe Observatory allowed him to repeat the kind of measurements from the Southern Hemisphere that Garstang had taken in the North. He found Pretoria “deadly uninteresting” and too pious – the whole place closed down on weekends. However, he was able to make world-class observations with the 1.9-metre telescope. Presenting his results later at a conference in the Netherlands, he was approached by Willie Fowler (later a Nobel Laureate) who said: “Young Warner, you have the first direct evidence of nuclear reactions taking place inside stars”.

OXFORD, TEXAS AND SOUTH AFRICA

After his PhD, Warner remained for a postdoc at UCL, during which time he returned to Pretoria. In 1965 he was awarded a Radcliffe Fellowship to

Balliol College at the University of Oxford. He remained in the post for two years, and he loved the university town. The only problem was that it did not have an observatory.

In 1967, Warner was headhunted to work as a spectroscopist at a recently established astronomy department at the University of Texas at Austin in the USA. The university had a great telescope, and Warner was able to spend a lot of time getting data. He stayed in Austin for five years, and this is where he really forged his career in spectroscopy. He also worked on high-speed photometry, moving from the long exposures of spectroscopy to the quick-exposure used to study things like pulsars. In 1968, Warner's team received a phone call from colleagues in Arizona, who wanted him to confirm what they believed to be the first-ever optical observation of a pulsar. Warner's team did, and published a confirmatory paper in the same issue as the original discovery was published in *Nature*.

Warner could have happily stayed in Texas for decades, but fate had other plans in store. He befriended an electrical engineer who was working as a technician on the new telescope being built in Austin to study planets. The engineer was keen to do a PhD, but the University of Texas would not allow him to do one without prior academic qualifications in astronomy. Instead, he applied to UCT in South Africa, which would allow him to enrol for a PhD based on the on-the-job experience he had obtained in Texas.

Warner himself followed his engineer friend a year later to become the first Head of UCT's new Department of Astronomy. His friend from Texas ended up being his first PhD student there. Warner had been persuaded to take the post by Jack de Wet, a South African mathematician whom he had befriended at Oxford. De Wet wrote to Warner while the latter was still in Texas, telling Warner that he was due to retire at Oxford and that he was returning to UCT as Dean of Science. “That changed everything,” says Warner. “I knew De Wet, I admired him. I wanted to go where he went.”

Warner remained head of UCT's Astronomy Department until 1999. During that time, the department grew – albeit slowly at first. The observation facilities were improving as well. The government established Sutherland in the

Northern Cape as the country's new astronomy hub. New telescopes were built alongside others that were moved there, including the one Warner had used for his observations a decade and a half before in Pretoria.

During the 1980s the government tightened the funding for astronomy, and Warner nearly left South Africa as a result. But as the democratic era dawned, he was given fresh resources by UCT's first black Vice-Chancellor, Dr Mamphela Ramphele.

THE BOOK LOVER

In addition to being an astronomer, Warner is a bibliophile of note. He was on the board of the South African National Library for ten years. In his own collection, three books stand out. The first is a copy of *Ure's Dictionary of Chemistry* dated 1825. It cost him two shillings and six pence at a second-hand bookshop in the town where he went to school. "It's a little bit out of date, but the content is fascinating," he says.

The second, a book from John Herschel's own library, cost him a month's salary when he was a Professor. Herschel's entire library was sold to an American medical doctor, but books from the collection cropped up after 2000, presumably because the owner had died. The book has Herschel's library stamp on it, and is a treatise on the principles of natural philosophy. "I'm the custodian of it," Warner says, proudly.

The third book is the oldest: *A history of the house of Northumberland from 1550 to 1750*. Basically, it is the household accounts of an old English fam-

ily. "It's a bit dull, but it's an important book for understanding the history of the aristocracy and it has a superb fore edge painting. Those are the three books that I turn to when I'm looking for something familiar and safe to read."

Warner has written several books and papers on the history of astronomy in South Africa. He considers the British polymath John Herschel, who lived and worked in the Cape from 1834 until 1838, "the greatest all-round scientist ever to live in South Africa". Warner suggested the Royal Society of South Africa name one of its medals after Herschel – a medal that Warner himself won in 1988. He is also one of the founders of the Academy of Science of South Africa (ASSAf).

However, Warner considers building up the astronomy department at UCT as his crowning achievement. When he took charge in the beginning, it consisted of only two people. Today there are so many staff and students that he can't remember the names of everyone. "It's a big department and I'm proud to have laid the foundation for it," he says. Without it and the people it has trained, South Africa would not have been in the position to build and run the ten-metre mirror SALT, which helped to win the bid to host the SKA.

Warner officially retired from UCT in 2004, but kept an emeritus post at the institution, and was later reinstated on the payroll as a senior scholar. He believes the future for astronomy is in good hands. "The future of astronomy in South Africa is enormous. I'm very impressed by what it has been possible to do," he says proudly.

| BRENDA DIANA WINGFIELD |

TOP THREE AWARDS

- HF Oppenheimer Fellowship Award, 2016
- Christiaan Hendrik Persoon Award (Gold Medal) of the Southern African Society for Plant Pathology, 2015
- African Union Regional Award for Women in Science, 2009

DEFINING MOMENT

When genes captured her imagination and directed her course of study.

WHAT PEOPLE DO NOT KNOW

I really am an introvert, all the tests show this BUT I have learned to improve on my abilities to deal with others. Having an extrovert husband has helped.



RARE SKILLS AT WORK

Professor Brenda Wingfield's research occupies a critical point in the wider field of biology: the intersection of biochemistry and genetics, being highly qualified in both fields. It is not surprising, then, that in addition to being a Professor of Genetics, she also holds (or has held) the Directorships in the University of Pretoria of the Molecular Screening Co-operative Programme and the Forest Molecular Biology Co-operative; and is a Programme Leader of the DST/NRF Centre of Excellence in Tree Health Biotechnology.

Being modest about her positions, though, she points out that both biochemists and geneticists are hesitant about her claims to having skills in both areas. Her qualifications, and considerable applied experience, however, give the lie to such hesitancy: she holds a Masters degree in biochemistry, statistics and genetics, and a PhD in microbiology which place her in the ideal position to undertake her award-winning, internationally recognised research in the fields of molecular mycology and (more broadly) plant pathology.

Wingfield was born in Northern Rhodesia (Zambia) and grew up in Southern Rhodesia (Zimbabwe), one of four children of an engineer – and was fortunate enough to be taught high-school biology by an exceptionally skilled and well-educated teacher. It was in these classes that she encountered not just general biology but 'genes' which captured her attention – and her imagination – a defining moment in her early years, which served to direct her into her chosen fields of study and research.

As did all high-school students in Zimbabwe, she wrote the United Kingdom school-leaving examinations and then a local examination – the M-level – and was the only student in her cohort to achieve a first-class pass in biology. Determined to study genetics, Wingfield enrolled for an undergraduate degree in the University of Natal in Pietermaritzburg and completed a BSc majoring in biochemistry and genetics.

TACKLING MEDICINE

By then, however, she had come to realise that without some medical knowledge, it would be very difficult to pursue her interest in genetics and,

since she had no intention of becoming a medical practitioner, she enrolled for a BSc Hons (Medical) degree at the University of Cape Town (UCT). As good fortune would have it, her arrival in the Department coincided with Professor Wieland Gevers' appointment and, although he wasn't her supervisor, it was he who created opportunities for her and her fellow students by encouraging and supporting them and spending considerable time with the students.

Wingfield recalls Gevers saying that he kept a copy of the most recent issue of *Nature* on his bedside table – something that made her think a good deal more consciously about what it might mean to be a serious academic.

She is disarmingly self-effacing about the next stage in her academic career. Her boyfriend, Mike Wingfield, had completed a Masters degree in plant pathology at the Stellenbosch University (SU) and was sponsored to undertake a PhD at the University of Minnesota. They agreed that Brenda should accompany him to the United States, and the only way in which this could be done was as his spouse.

At the age of 21, they were married and set off to St Paul (home to the Agriculture Campus of the University of Minnesota). For the first six months in the States, Wingfield describes herself as having been "a lady of leisure" and concentrated on improving her sewing skills by taking classes. When, however, her husband was required to complete a course in statistics, he suggested that she register for the course in order to study together. The course turned out to be a critical moment in her career: from sewing to statistics to scientist. She so enjoyed the course that she went on to register for the following course in statistics and then registered for a Masters degree in biochemistry, with supporting courses in genetics and statistics.

It was also a critical moment in another sense, as it was the beginning of what has since become a lifelong, highly productive and complementary research partnership between the Wingfields.

She completed her Masters degree under the supervision of Dr Thomas Guilfoyle in 1984 and returned to South Africa, taking up a position as re-

search officer in the Department of Biochemistry at UCT, headed by Claus von Holt, where she ran the Recombinant DNA laboratory, undertook the first DNA sequencing project in the Department, and advised graduate students on the recombinant DNA aspects of their research projects. In the course of her research at UCT, she worked with colleagues in the Department of Microbiology (headed by David Woods) including Frank Rob, Doug Rawlings and Ed Rybicki. She subsequently moved to the Institute for Biotechnology at SU joining the staff as a researcher, and working with Professor Hennie van Vuuren. In this position, she was instrumental in establishing the SU Recombinant DNA laboratory and the microbiology research system which she then ran.

In 1986, six months into her first pregnancy, Wingfield registered for a PhD degree in microbiology at the SU studying killer and neutral wine yeasts under the supervision of Professor Izak Pretorius. Four years later, she completed her PhD – six months into her second pregnancy. It was clearly a time of demanding scientific research and motherhood, which Brenda characterises as one of great opportunities and excitement.

By this time, Brenda had moved (following her husband, she wryly remarks) to Bloemfontein where she was appointed as a lecturer and researcher in the Department of Microbiology and Biochemistry in the University of the Free State (UFS). In her nine years at UFS, Brenda was promoted to a senior lectureship and then to an Associate Professorship, in which position she and her colleagues set up a molecular taxonomy programme that focused on rRNA and rDNA sequencing that was relevant to the work of research groups in the department.

MULTIPLE DIRECTORSHIPS

In 1998, Wingfield was appointed as a full Professor in the Department of Genetics in the University of Pretoria (UP). In 1994, while still holding her Professorship, she took up the Directorship of the Molecular Screening Cooperative Programme; in 1999, the Directorship of the Forest Molecular Biology Cooperative Programme and, in 2004, the Programme Leadership of the Department of Science and Technology/National Research

Foundation (DST/NRF) Centre of Excellence in Tree Health Biotechnology. From 2009 through to mid-2016, and while continuing her teaching and research, Brenda was the Deputy Dean for Research in the UP Faculty of Natural Agricultural Sciences and was, for about seven months, the Acting Dean of the Faculty.

Her status as a research scientist is evident not only by her 350 accredited publications and hundreds of popular articles and commentaries, but also by the substantial number of invited lectures she has given, and the more than 45 international research visits she has made over the past 25 years. She undertakes all her work on the basis that excellence is the only benchmark of significance, a lesson she learned working in departments with a strong research ethos – such as those at UCT, SU and Minnesota – and now at UP.

In this light, she is of the view that she has yet to make her most significant contribution to science – although she is most proud of having been the first African researcher in Africa, to have sequenced a fungal genome using an African laboratory, demonstrating that this could be done without 'outsourcing' the sequencing to the global north.

One of Wingfield's great passions is, in fact, promoting the importance of scientific research being undertaken, and seen through to completion, in Africa. She believes that 'outsourcing' the finalisation of research processes to the global north leaves Africa out of worldwide competition and research networks, and that as long as that situation is perpetuated, African science will always be seen to be second best, when there is no reason for this to be so. In line with this lies her commitment to supporting as many postgraduate students as possible, in order to contribute to a growing cohort of young scientists who share her commitment to excellence, and to strengthening scientific research outputs in Africa.

In addition to being a leading scientist, Brenda Wingfield is an active supporter, and member or fellow, of some 30 scientific and scholarly associations. In 2008, she was elected as a Fellow of the Royal Society of South Africa and in 2009, The World Academy of Sciences.

She is also a committed, effective (and valued) teacher, having consistently presented undergraduate courses; nurtured (so far) close to 50 Honours students and supervised 52 MSc and 57 doctoral students.

Her message to these young scientists is, of course, about excellence, and has also been about the privilege and joy that an academic career brings to those who are fortunate enough to follow it. She encourages her post-graduate students to follow her example of ensuring that she plans each day, week and month so as to maximise having fun – enjoying the excitement and rewards of high-level research. She is firmly of the view that losing the sense of pleasure that scientific work offers is often a signal that the time has come to follow a different career.

She considers herself fortunate to have found herself working in close co-operation with her husband, and she reminds her students that they should think carefully about the partners with whom they chose to spend their lives. Mutual support, and a recognition of the complementary skills on which a team can draw, go a long way, she believes, in furthering research success – and, of course, excellence. Into this mix, she adds personal strengths that partners can bring to their careers. She considers herself to be inclined to be introspective, although anyone who knows her would hardly guess this to be so. But working in a team has, she points out, more than compensated for that trait.

Wingfield's career has been and continues to be rich and diverse – and difficult to characterise in terms of highlights since there are so many. Per-

haps, though, there are a few moments or developments that mark key points in her life and work.

Undoubtedly, the first of these would have to be her introduction to genes (and their DNA bases) and genetics as a high-school student – thanks to an inspiring biology teacher. Brenda's teenage fascination with the field led to her decision to follow this area of research and influenced each of her subsequent academic choices, and her successful career.

In her formative years, she encountered leading South African and international scholars in her field and made the most of those experiences, learning more than just the 'science'.

And then there is Wingfield herself: happily aware of the privileges that come with an academic career, full of laughter and *joie de vivre*, and totally committed to supporting the next generation of scientists in her field – inspiring them with her own sense of the importance of scientific discovery. In this regard, she is determined to continue her work as long as she possibly can, the notion of reaching the peak of her work at 60 being both unrealistic and unacceptable.

All told, a rare combination of circumstances, commitment and character, which have informed and shaped her life and her remarkable achievements.

| MICHAEL (MIKE) JOHN WINGFIELD |



TOP THREE AWARDS

- The Christiaan Hendrik Persoon Award (Gold Medal) of the Southern African Society for Plant Pathology (one of only six awards of this honour made by the SASPP up to 2015), 1999
- The National Science and Technology Forum (NSTF) (first-ever individual award made), 1998
- The Kwame Nkrumah Science Award of the African Union, 2013

DEFINING MOMENT

Moving to Stellenbosch as an agricultural researcher.

WHAT PEOPLE DO NOT KNOW

He lost 11 balls in an 18-hole round of golf. He mixes his own tea, a blend of 40% Darjeeling, 40% Assam and 20% Lapsang Souchong.

CARING FOR THE TREES

Professor Michael Wingfield is a National Research Foundation (NRF) A-rated scientist who specialises in studying the health of trees, whether in the wild or in plantations.

As he insightfully points out, an avocado tree in a Lowveld orchard is the same tree that one will find growing wild in the forests of Venezuela. And all other plantation trees in South Africa are native to another, non-South African environment. Whether this is a good thing or not, he notes, is a subject on which he can readily argue from both positions – while pointing out that if the 'indigenous only' position were taken to its logical conclusion, South Africa would, for instance, not be growing wheat, or grapes.

The critical issue, however, is that of forest health – whether the forests be indigenous or not. Sugden *et al*, for instance, have this to say:

Forests and woodlands cover about 20% of the earth's land surface, spanning all but the highest latitudes. In the millennia since humans dispersed across all forested continents, we have transformed large areas of natural forest. Only a fraction of the forests present centuries ago have escaped human influence... Humans have... introduced new species, including pests and pathogens of trees... Even though modern forests are generally much altered from their natural state, their 'health' still matters. It will dictate whether forests persist and function into the future, sustaining wildlife, producing timber, sequestering carbon, and performing other services.

In a paper in the same edition of *Science*, written by Wingfield and his co-authors, they point out that:

Forests and woodlands ecosystems are a hugely important natural resource, easily overlooked and undervalued. Globally, one in six people is estimated to rely on forests for food and many more depend on forests for other critical ecosystem resources... However, the health of forests, both natural and managed, is more heavily threatened at present than ever before.

The areas of science in which Wingfield works are of considerable significance in terms of human well-being, economic stability and environmental strength and environmental health in far more general, global terms.

Wingfield was born on the KwaZulu-Natal south coast and soon after, his parents moved to Harare (then Salisbury) where they lived until he was about six. Thereafter, they returned to South Africa, settling in Irene, outside of Pretoria. He grew up with his parents and grandfather, who had built a home in Irene, amidst the grasses of the Highveld. He has been interested in nature from his young days and recalls feeding an asprin to a frog and then dissecting it to see what happened, and also growing seeds of various kinds and checking their growth and development; a Gerald Durrell of the Southern Hemisphere, whose interest moved decisively into the Plant Kingdom. Wingfield was close to his grandfather, who had a PhD in English literature and was one of the first people in South Africa to be trained in forestry in Tokai.

EARLY YEARS

He enrolled at the University of Natal in Pietermaritzburg where he completed a BSc degree in botany and plant pathology. During his holidays, he worked for the Botanical Research Institute in Pretoria where he gained considerable practical experience from the institute staff, and then completed a BSc (Hons) degree in plant pathology. In his Honours year, he met Brenda Fairbairn, then a first-year student. They were later to be married and to become not just a family but also a working partnership.

At that stage, Wingfield wished to continue with postgraduate studies in Pietermaritzburg but as his degrees had been part-funded by bursaries from the then Department of Agriculture, he was required to 'work-off' his funding. In 1978, he became an agricultural researcher in the Plant Protection Research Institute in Stellenbosch. This move was a defining moment in his career. Even at that early stage in his career, Wingfield was a scientific entrepreneur, and started the first Forest Pathology Programme in South Africa while also studying for a Masters degree at Stellenbosch University, which he completed in 1979. He also developed a passion for growing peanuts and the diseases to which they are subject – but forests and their trees steadily drew him above ground again.



During this time, he was introduced to Walter (Wally) Marasas, a world-renowned mycologist who helped him to write his first international scientific article – *Verticicladiella alacris* sp. nov., associated with a root disease of pines in South Africa – published jointly with Marasas in the *Transactions of the British Mycological Society*. Yet another defining moment he says – his meeting with exactly the right person at the right moment in his life.

Wingfield notes that, while this article came back from the editors with the comment “perfect paper”, his second paper was, “so black and blue” that he felt seriously depressed – although he notes that after publishing over 700 research papers, he still has submissions turned down: such is the nature, and importance, of rigorous review processes, as he reminds his postgraduate students and postdoctoral fellows.

His Masters degree completed, Wingfield set off for the University of Minnesota in 1980, where he completed his PhD in 1983, during which time he also worked as a research assistant. On returning to South Africa in 1984, he was employed as a senior, and then specialist, researcher in the Plant Protection Institute in Stellenbosch, moving in 1988 to the University of the Free State to become an Associate and then full Professor in the Department of Microbiology and Biochemistry (with a co-appointment in the Department of Plant Pathology). In 1994, he was the Mondi *ad hominem* Professor of Forestry Pathology and a Visiting Professor for Plant Pathology at Iowa State University.

In 1998, he joined the University of Pretoria (UP) as Professor and founder of the Forestry and Agricultural Biotechnology Institute (FABI), where his Mondi professorship was re-instated. After a short period of research in Canberra, he returned to UP and FABI.

CONTRIBUTION TO FORESTRY

Wingfield's highly cited research in his field, conducted in many different countries of the world but with a strong focus on Africa, has led to the discovery of some of the most important pathogens of trees grown commercially in plantations. It has also elucidated elements of the biology and

global movement of many of the most important pests and pathogens of trees, substantially contributing to new management options and solutions to problems that have reduced losses to industry. Based on his research reputation, he has been a long-term advisor of many major forestry corporations in South Africa and globally.

Amongst his most important contributions to forestry has been the role that he has played as an advisor to more than 70 PhD and an equal number of MSc students, many of whom now hold very senior positions globally. He has also worked closely with almost 60 postdoctoral fellow and visiting scholars, primarily during his years at FABI at the University of Pretoria. In this regard, he has been heavily involved in providing education opportunities for students, capturing his deep commitment to research and education particularly in the developing world. He was responsible for establishing the Tree Protection Co-operative Programme (TPCP) in 1990 to minimise the impact of pests and pathogens threatening commercial forestry in South Africa and this has become the largest single tree health project in the world. It also formed the catalyst for the establishment in 1998 of the FABI of which he was the founding Director.

FABI has rapidly gained substantial international recognition for research excellence and the post graduate education of large numbers of students, many from disadvantaged backgrounds.

Wingfield has published widely on the topic of tree health in more than 700 research papers and six books, and he has presented many invited plenary addresses and other public lectures globally. Research, he says, is a compelling, addictive process. He has served or still serves in many distinguished positions including the boards of institutions such as the Council for Scientific and Industrial Research (CSIR), the International Union for Forestry Research Organisations (IUFRO) and the *Centraalbureau voor Schimmelfcultures* (Netherlands), and in most of these for extended periods of time. He has received many awards and honours for contributions to education, research and industry, in South Africa and elsewhere in the world.

While his curriculum vitae is almost 200 pages long, he says it is team work, collaboration and long-standing friendships that have typified his almost 30 years of active research and he never tires of being fascinated by the

amazing 'stories' that emerge from his research on the health of trees. That Wingfield values such cooperation is also reflected in other ways. He feels, for instance, that the astonishing number of scientific bodies to which he has or continues to make substantial contributions; his publication record, and, most critically, his remarkable list of high-level awards, all "belong to, or are supported by others". There are two facets to this, he explains. Scientists who have received those awards more recently have, he points out, won them in the increasingly competitive world of scientific research – in which, ever higher standards are demanded. More importantly, he says, the awards he has received are the result of team work and collaboration: while he received the awards, it has been those who have worked with him who have made them possible. "Brenda (his wife, who is an NRF A-rated scientist in the field of fungal population genetics) probably deserves half of my awards – but how does one say to an organisation 'why not give that to my wife?'" It is essential, he says, that scientists should be appreciative of the people who have helped to make them who they are.

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A. Academy of Science of South Africa (ASSAf) Publications

C. ASSAf Policymakers' Booklets

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Academy of Science of South Africa (ASSAf), (2017). Legends of South African Science.

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